PERFORMANCE DEMONSTRATIONS OF ALTERNATIVE SCREEN RECLAMATION PRODUCTS FOR SCREEN PRINTING

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NOTICE

This document summarizes the information collected from printers who voluntarily participated in this project to evaluate alternative screen reclamation chemicals. These evaluations were conducted as demonstrations under the variable conditions of production. The results reported in this document are, in large part, subjective and relied on the experience and judgement of the printers who used these alternative products.

This report has been subjected to U.S. Environmental Protection Agency peer and administrative review and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. This document is intended to provide printers with information on the performance and cost of alternative screen reclamation products. Compliance with environmental and occupational safety and health laws is the responsibility of each individual business and is not the focus of this report.

This effort has been funded by the United States Environmental Protection Agency under Contract No. 68-D2-0175, Work Assignment 2-21.

FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of materials that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency (EPA) is charged by congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The National Risk Management Research Laboratory is responsible for planning, implementing, and managing research, development, and demonstration programs to provide an authoritative, defensible engineering basis in support of the policies, programs, and regulations of the EPA with respect to drinking water, wastewater, pesticides, toxic substances, solid and hazardous wastes, Superfund-related activities, and pollution prevention. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

The cost and performance summaries presented in this report, in conjunction with risk estimates, are essential information for printers to use when selecting products that are safer for employees and the environment. Associated risk estimates were calculated as part of the overall Design for the Environment (DfE) Screen Printing Project and are presented in the project report titled, *Cleaner Technologies Substitutes Assessment* (CTSA), EPA document EPA744R-94-005. Since variables such as ink type, substrate printed, volume, and equipment are different in every print shop, a product that is efficient and cost effective for one facility, may not be the right choice for another shop. With these variations in mind, this document presents the results of the performance demonstrations of several alternative screen reclamation products and the associated costs, without ranking or comparing any of the products. The information on performance is largely qualitative and is based on the opinions of the printers who used these substitute products in their facilities for one month. Using the information presented in this report, the printer can then estimate what products are likely to be successful in his/her particular facility.

E. Timothy Oppelt, Director
National Risk Management Research Laboratory

ABSTRACT

This project evaluated environmentally-preferable products for the screen reclamation process in screen printing during month-long demonstrations at 23 printing facilities nationwide. Through the Environmental Protection Agency (EPA) Design for the Environment Printing Project, printers, the EPA, reclamation product manufacturers, and the screen printing trade association worked together to evaluate alternatives to the hazardous chemicals commonly used during screen reclamation. A total of ten "product systems" (which include an ink remover, a stencil or emulsion remover, and a haze remover) were voluntarily submitted by manufacturers for evaluation. Additionally, one individual ink remover, and two substitute technologies were demonstrated.

Performance, cost, and risk were evaluated for each alternative chemical system. The portion of the project documented in this report includes the performance characteristics and the costs. The risk assessment information is available in the EPA project document, titled *Cleaner Technologies Substitutes Assessment* (CTSA), EPA document EPA744R-94-005.

Performance was evaluated in two phases: (1) laboratory testing to ensure the products were generally effective, and (2) in-field demonstrations to evaluate product effectiveness in a production situation. In general, most emulsion removers worked very well, but the success with the ink and haze removers was mixed. Costs of switching from a baseline reclamation system to an alternative system were estimated based on the cost of: chemicals, the labor time to reclaim the screen, rag use, and waste disposal. Fourteen facilities would realize reduced costs for screen reclamation by switching to an alternative product. The other nine facilities would experience increased costs.

Two alternative technologies were also evaluated. Using the first technology, a high pressure (3000 psi) water blaster, the quantity of chemicals needed and the time required for reclamation were reduced. Based on limited, preliminary demonstrations, the second technology evaluated, a sodium bicarbonate spray, may have potential for reclaiming screens used for printing with solvent- or water-based inks.

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ACKNOWLEDGEMENTS

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Several diverse groups worked together to make this project possible. The contributors include the EPA Office of Pollution Prevention and Toxics Design for the Environment staff, particularly Kathryn Caballero, Stephanie Bergman, and Jed Meline, and the Screen Printing Association International (SPAI), particularly Marcia Kinter and Dan Marx. The performance demonstrations would not have been possible without the help of the screen reclamation product manufacturers who donated their products. These manufacturers, listed below, can be contacted through the information given in Appendix H.

Amerchem, Wood Dale, IL
Autotype Americas, Schaumberg, IL
Ciot International Services, Whippany, NJ
Franmar Chemical Associates, Normal, IL
Hydro Engineering, Inc., Salt Lake City, UT
Image Technology, Inc., Anaheim, CA
KIWO, Seabrook, TX
Nichols and Associates, Burnsville, MN
Ruemelin Manufacturng, Milwaukee, WI

The role of the printing facilities who volunteered their time to demonstrate the alternative products was essential to the success of the project. The efforts of these printers were greatly appreciated:

Action Graphics, Louisville, KY
Artcraft, Portland, OR
Burlington Graphic Systems, Union Grove, WI
Coburn Corporation , Lakewood, NJ
Fastamps and Fasigns, Randolph, MA
Gangi Studios, N. Hollywood, CA
Gillespie Decals Inc., Wilsonville, OR
Identification Products, Bridgeport, CT
Ivey-Seright International, Inc., Seattle, WA
Karagraphic, Kent, WA
Leading Edge Graphics, Minnetonka, MN
Masterscreen Products, Portland, OR
M&M Displays Inc., Philadelphia, PA
Mobius, Inc., Eugene, OR
Modagraphics, Rolling Meadows, IL
Morrison & Burke, Inc., Santa Ana, CA
Nameplate & Panel, Carol Stream, IL
Paramount Screen Print, Milwaukee, WI
Philadelphia Decal, Philadelphia, PA
Phillips Plastics Co., Fredonia, WI
Quantum Graphics, Redmond, WA
Royal Label, Boston, MA
Screen Process Specialist, Plymouth, WI

SECTION I

INTRODUCTION

The Screen Printing Performance Demonstrations summarized in this report provide critical information on the performance of alternative screen reclamation products and technologies for the Design for the Environment (DfE) Printing Project. One goal of the DfE Printing Project is to encourage printers to use risk and hazard information, along with performance and cost data, to make informed, environmentally-sound decisions about the chemicals and processes they use. This non-regulatory, voluntary project is a cooperative partnership between the EPA, the Screen Printing Association International (SPAI), printers, and manufacturers of printing supplies. As one of the initial tasks for this project, industry representatives prioritized certain processes as the focus for exploration of environmentally preferable alternatives. In screen printing, screen reclamation was selected as the focus area for the DfE project. Screen reclamation is a cleaning process where ink and the print image are removed from a screen so the screen can be reused for another job. It is a three step process where the ink, the stencil (or emulsion), and any remaining stain (known as "haze") are removed sequentially. Typically a different product is used for each step, and in this project the three products (ink remover, emulsion remover, and haze remover) are referred to as a product system.

In support of the EPA Office of Research and Development (ORD), the DfE staff within the Office of Pollution Prevention and Toxics (OPPT) conducted the Performance Demonstration portion of the DfE Printing Project. The performance of substitute products, voluntarily supplied by manufacturers, was evaluated under both laboratory conditions and by printers under actual production conditions. This performance information was an essential element of the complete analysis of the product systems, which is documented in the Cleaner Technologies Substitute Assessment (CTSA). The CTSA integrates performance data with information on the costs and risks, evaluated in a separate effort, associated with the products demonstrated. Because all products were evaluated following the same protocol in a neutral forum, the CTSA provides printers with a more complete assessment of alternative products than has otherwise been available from one source.

When printers consider alternative chemicals, performance of the product is often their primary concern. This report summarizes the performance data collected during performance demonstrations with alternative screen reclamation products carried out between January and April 1994. The data collected include information such as, time spent on screen reclamation, volume of product used, and appearance of the screen after reclamation. In addition to the data collected during demonstrations in printing facilities, laboratory demonstrations were also conducted at the Screen Printing Technical Foundation (SPTF).

The intent of the SPTF evaluations was to assure that the product systems sent to printers would provide an acceptable level of performance. Additionally, the SPTF evaluations provided another set of observations with which to compare in-facility demonstration results. In-facility demonstrations were designed to last one month and were undertaken so that the long-term effects of the product systems could be evaluated under actual production conditions at printing facilities. It should be noted that the performance demonstrations were not rigorous scientific investigations. Instead, much of this document reports the printers' experiences with and opinions of these products as they were used in production at their facilities.

In addition to performance information, the costs and risks for each of the substitute product systems were evaluated. The risk information is too extensive to be included in this document, but can be found in the CTSA. The cost estimate for each reclamation system included the cost of: labor time spent to reclaim the screen, the average quantity of reclamation product used, the rags used, and the hazardous waste disposal for RCRA-listed chemicals. To compare the costs of the substitute systems to a known system, a baseline was established using a traditional solvent-based screen reclamation system. The traditional system used in the comparison consisted of lacquer thinner as the ink remover, a sodium periodate solution as the emulsion remover, and a xylene/acetone/mineral spirits/cyclohexanone blend as the haze remover. These chemicals were selected because screen printers indicated they were commonly used in screen reclamation. For all cost estimates, it was assumed that the chemicals were applied manually to 6 screens per day, each 2,127 in^2 (approximately 15 ft^2) in size. It is important to note that the costs of the alternative products are compared to the baseline product system and not to the actual system currently in use at the facility. A baseline was selected to obtain the most useful and consistent information. Comparing the demonstrated products to each facility's current product would have been highly inconsistent because of the range of products in use at the volunteer plants. Additionally, such a comparison would not be representative of printers, because these facilities volunteered to assist in identification of environmentally preferable products, which may indicate that they are more concerned and aware of environmental issues than the average printer. For example, several of the facilities were already using products that were nearly identical to the products being demonstrated. With the variability among the products currently in use by the participating facilities, it was determined that a comparison of the demonstration products to a baseline product would give printers more useful information than a comparison to products currently in use.

A total of ten alternative screen reclamation systems were submitted for the demonstrations. Each product system was sent to two or three facilities in addition to the testing done at SPTF prior to the on-site demonstrations. In most cases, the results for the same product system varied somewhat from one facility to the next. For the ink and haze removers the products generally received a better performance evaluation at SPTF than they did in the field demonstrations. The performance of the majority of these products was considered fair by the printers, however there are some exceptions where the performance was consistently evaluated as good, both at SPTF and at the printing facilities. The performance of 8 out of the 10 emulsion removers submitted was very good. Both at SPTF and at the facilities, the emulsion removers removed the stencil quickly and completely and many of the printers wanted to continue using these products after the demonstrations were over.

Background on the screen printing process, screen reclamation, and the environmental issues associated with the industry are described in Section II. Details on the demonstration methodology used during laboratory tests at SPTF and during field demonstrations at printing facilities are given in Section III. Section IV describes the printing facilities that volunteered their plants for the demonstrations. A general description of the types of products submitted is given in Section V. For each product system, the SPTF testing results and the facilities' evaluation of the products are summarized in Section VI of this report.

The summaries in Section VI provide a description of the product performance and the cost summary for each product system, but do not rank or endorse any product systems. As the printers involved in this project pointed out, the specific operating conditions of a print shop (e.g., ink type, mesh count, drying time) can influence the product performance significantly. For this reason, selected facility characteristics are also detailed in the Section VI evaluations. It should be noted that the trade names of the products are not used in this report nor were they given to individuals involved in performance demonstrations. Instead, the chemical formulation of each product is listed in Table 6.1 at the beginning of Section VI. Using the descriptions of product performance in conjunction with the chemical formulations table (Table 6.2), printers can determine which product system(s) they think would be most suitable for their facility. Once that determination is made, printers can contact their distributors, inform them of the type of product they are looking for (based on the chemical composition), and ask for a recommendation on such a product system. A list of the participating manufacturers is given in Appendix H of this report. The list includes telephone numbers and contact names so printers can also directly contact these manufacturers if they prefer. For more information on the risks associated with each product system, the printer should refer to the EPA's CTSA Screen Reclamation document.

SECTION II

BACKGROUND ON SCREEN PRINTING

SCREEN PRINTING PROCESS

Most printing processes use an impervious metal, plastic, or rubber plate to transfer an image to a substrate. Screen printing, however, does not use such a system; instead ink is forced through the unblocked portion of a porous screen onto a substrate. The image is defined by a stencil which is adhered to the fabric screen. The finely woven screen mesh is usually stretched tightly over a wooden or aluminum frame which forms a shallow well where ink is applied. Ink is placed on the screen and is pressed through the mesh with a rubber blade (a "squeegee") onto the substrate. Ink will pass through the mesh and onto the substrate except in the areas where the stencil has been applied. The screen is raised and the printed substrate is either manually placed on a drying rack or on a conveyor which moves the printed material into a drying unit. As the printed substrate moves out from under the screen, another substrate is put in its place. When the screen is lowered again, the squeegee is drawn across the screen and the image is printed again on the next substrate.

Screen printing offers the printer more versatility than most printing processes in that it can deposit ink at variable thicknesses, including relatively heavy deposits, with high quality pigments on almost any surface, regardless of size or shape. This variability in ink thickness and print substrate allows the screen printer to print brilliant colors, and durable products that can withstand harsh weather conditions (for outdoor signs) and laundering (for printed T-shirts). Substrates commonly used by screen printers include paper, paperboard, plastics, glass, metals, textiles, and many other materials. Ink types used in screen printing include solvent-based, UV-curable (ultraviolet curable), water-based, and plastisol inks. The choice of ink depends on the substrate being printed and the equipment available in the facility. This project focused on screen printers who print on plastic and vinyl substrates.

<u>Screen Reclamation</u>

An imaged screen can be reused multiple times to print the same image or the stencil can be removed so a different image can be applied. Removal of the image and ink from the screen is called the reclamation process. Due to the high cost of the screen material ($25 - $45/yard for 40" wide mesh) and the labor required to replace a screen, most printers reclaim their screens for reuse. According to a 1990 SPAI survey of the industry, 90.3 percent of screen printers reclaim screens daily. Screen reclamation techniques vary from one facility to another, however, the three basic steps typically performed to reclaim a screen are: ink removal, emulsion removal, and haze removal.

Ink removal is the first step in reclaiming a screen. Generally, facilities scrape off excess ink and chemically remove ink residue from the screen at the end of every press run, regardless of whether the screen is to be reclaimed or reused with the same image. The 1990 SPAI Industry Survey found that 97.5 percent of the printers responding use an ink remover daily. In most facilities, an ink remover product is sprayed, poured, or wiped onto the screen. The ink remover chemical and the ink are both wiped off or rinsed off the screen.

Ink removal precedes emulsion removal (also called stencil removal) so that excess ink does not interfere with the removal of the stencil. The predominant emulsion removal chemical in use today is sodium metaperiodate. It is sold either as a powder that is mixed with water at the facility or in a water solution as a liquid. The liquid is typically sprayed on the emulsion, rubbed in with a brush which loosens the stencil and is rinsed off with a pressurized water wash.

After the emulsion is removed, a haze or a "ghost" of the image may remain on the screen. If the haze is dark enough, it may act as a stencil by blocking the ink from passing through the screen. A light image, called a ghost, will then appear on the substrate during the next printing job. Haze may also interfere with the adhesion of the next stencil. The haze is caused by ink or stencil that gets caught in the areas between the overlap of the screen threads or that is stained into the threads of the screen. If a haze is visible or suspected, a haze remover is applied before reusing the screen to avoid printing a ghost in the next print run. Haze remover is typically either a paste that is brushed onto the affected area, or a liquid that is sprayed onto the screen and then brushed in. The chemical and the haze are then rinsed off, typically with a high pressure washer. Haze remover chemicals are often caustics and can damage or weaken the mesh if used excessively or if allowed to remain in contact with the mesh for too long.

The ink remover, the emulsion remover, and the haze remover are sometimes sold together as a screen reclamation "product system." For the DfE Performance Demonstration Project, manufacturers were encouraged to submit complete product systems. When purchasing a product system, as opposed to buying the individual products, the printer is assured that the products are designed to work together and that there will be no chemical incompatibilities between the system components. A total of ten product systems, one individual ink remover, and two alternative technologies were evaluated by the DfE Screen Printing Project.

<u>Environmental Concerns Associated with Screen Reclamation</u>

Screen reclamation was selected as the focus area of this project for several reasons:

- **Screen reclamation products often contain highly volatile organic solvents.** Depending on the amount of product used, federal, state, or local regulations may limit the amount of volatile organic solvents used in the printing facility. In order to meet regulatory requirements and to protect the health of the workers, many printers are looking for less volatile cleaners.

- **Wastewater from screen reclamation typically goes directly down the drain.** According to a 1992 survey by Screen Printing magazine (printed in the April 1992 issue of Screen Printing), 191 out of 250 companies (76 percent) reported they send unfiltered waste down the drain (to sewer or septic). Ink, emulsion, and/or reclamation chemicals are likely to be in the unfiltered rinse water which could lead to health and environmental problems as the wastewater goes to a treatment facility, a waterbody, or a septic system.
- **Confusion over products that claim to be "biodegradable," or "drain-safe."** Although a given product may itself be safe to rinse down the drain, once it is mixed with ink or emulsion, drain disposal may not be permissible. Also, confusion surrounding the term "biodegradable" is widespread among printers; each manufacturer, regulator, and printer may have a unique definition for the term. It is important for printers to check their local, state and federal water regulations prior to discharging such a product.

The CTSA addresses these issues by presenting information on the costs and benefits associated with different screen reclamation options, such as occupational exposure concerns, cost differences, and performance effectiveness. The Performance Demonstration portion of the project concentrated on evaluating and documenting the performance of the alternative product systems.

SECTION III

PERFORMANCE DEMONSTRATION AND COSTING METHODOLOGY

PERFORMANCE DEMONSTRATION METHODOLOGY

Performance evaluations were conducted in two distinct phases: (1) the Screen Printing Technical Foundation (SPTF) evaluated each product system under controlled and consistent laboratory conditions; and (2) volunteer printing facilities nationwide collected much of the same information, but did so under the more variable conditions specific to their production runs. The testing methodology for both phases of the demonstrations was developed by consensus with the involvement of EPA, SPAI, individual screen printers, and manufacturers and suppliers of screen reclamation products and equipment. Due to the numerous variables associated with screen reclamation, the work group agreed that a rigorous scientific test of screen reclamation product systems would be difficult to develop. The group decided that it would be preferable to rely on the seasoned judgment of screen printers in evaluating the effectiveness of the alternative products. Additionally, the group felt that a month-long demonstration at the volunteer facility was required in order to identify the types of problems that occur only after repeated uses of the product on the same screen. For example, a product may cause gradual damage to the screen mesh that does not immediately affect print quality and is not visually noticeable until after multiple applications on the same screen.

Laboratory Testing Methodology

The intent of the SPTF evaluations was to assure that the product systems sent to printers would provide an acceptable level of performance. Screening at SPTF also provided another set of observations to compare with in-facility demonstration results. At SPTF, each product system was tested on three imaged screens; one with solvent-based ink, one with UV-cured ink, and one with water-based ink. One of the most important aspects of the SPTF methodology was that the evaluations were conducted under consistent conditions for all screens (e.g., tension, mesh type, emulsion type, thread count, image). In addition, the same technician conducted the evaluations for all product systems at SPTF. The technician recorded the following information: amount of product used, time spent on each reclamation step, level of effort required, and a qualitative assessment of product effectiveness and screen condition. A complete description of the SPTF methodology and parameters used is included in Appendix G.

Field Demonstration Methodology

Each printer evaluated the effectiveness of one screen reclamation product system. In most cases, the system included an ink remover, an emulsion remover and a haze remover. The facilities were responsible for reclaiming up to 12 screens per week over a thirty-day period utilizing the specified product system and recording the product's performance for each screen. (See Appendix F for the complete Facility Demonstrations Methodology).

SPAI recruited volunteer screen printers who print on plastic and vinyl substrates from across the country. EPA and SPAI staff matched the submitted product systems to volunteer printing facilities based on existing equipment, ink type, and current practices. Most product systems were evaluated in two or three facilities to provide performance data from different operating and ambient conditions. Prior to shipping product systems to printers, SPAI repackaged products or removed identifying marks and brand names so that those printers evaluating the products did not know the manufacturer or product name. Masked MSDSs and application instructions were also developed and were shipped along with the product systems to each facility.

Prior to the start of the demonstrations, a project observer was assigned to each facility. Observers were not EPA employees, but were drawn from the staff of Abt Associates Inc. and its subcontractor, Radian Corporation. For each of their designated facilities, the observer was responsible for collecting background information, visiting the facility on the first day of alternative product use, following the facilities progress throughout the demonstrations, and reporting the results. Before the observers scheduled their on-site visits, each facility received a Facility Background Questionnaire (see Appendix A). The data from the questionnaires were used for several purposes. First, the questionnaires were used to collect facility background information such as the number of employees, the facility's system for tracking screens, and the types of products printed. This information was used to help explain the different experiences of the two or three facilities who demonstrated the same alternative system. Second, the facility's current application procedures were reviewed to determine if they were similar to the application method recommended for the alternative product. Where possible, the project attempted to minimize changes in application techniques when switching over to the alternative product system. This was done because it was assumed that screen reclamation employees would be most receptive to new products that caused the least disruption of their normal routine. Third, information was collected on the chemical composition of the facility's current screen reclamation products to determine if there would be any incompatibilities between the alternative products and the facility's standard products that had previously been applied to the screen. In cases where the standard and alternative products were chemically very different, the possibility of incompatibilities existed and may have influenced the product performance. Cases where this could have occurred are noted in the text discussing performance results in Section VI.

After the Facility Background Questionnaire was completed, alternative products were shipped to the volunteer printing facilities. Before the facility could start using the products, the assigned observer visited the plant. During the visit, the observer first explained the goals of the project to all employees who might be using the alternative products. Next, the observer watched one screen being cleaned using the current screen reclamation procedures and recorded information about the current product system's performance on an Observer Evaluation Sheet (see Appendix B). Then the observer explained the application techniques of the alternative product system. The observer then watched the reclamation of three different screens with the alternative products and recorded information on Observer Evaluation Sheets. This routine allowed the observer to verify that the employees understood how to use the alternative product system and how to record data on the alternative system. Information collected on the Observer Evaluation Sheets included:

- **Screen condition:** screen size, thread count, mesh material, ink type and color, emulsion type, number of impressions of previous run.
- **Facility ambient conditions:** temperature, humidity, ventilation.
- **Reclamation procedures:** application method used for ink remover, emulsion remover, and haze remover; drying time between each reclamation step.
- **Product usage:** quantity of product used, the time it took to clean the screen, the effort required.
- **Screen inspection:** effectiveness of each product, evaluation of print image quality after reusing the screen.

After the observer's visit, the facility continued to use the alternative products for one month. During this time, facility staff recorded performance information on the alternative product systems for up to 12 screen reclamations per week, using the Printer Evaluation Sheets. Using evaluation sheets (see Appendices C and D), the printers recorded much of the same information on product performance that the observers collected during their site visit. The evaluation sheets for the printers, however, were less detailed to minimize the printers' record-keeping burden. Forms were kept short and simple to increase the likelihood that data would be recorded consistently and completely.

To supplement the information recorded by the printers, each week, the DfE observer telephoned the facility staff for an update on the product system's performance. Through these calls, the observer was able to determine if any changes were made in the way the products were used, and if the facility was having any problems with the products. These calls were documented in telephone logs (see Appendix E) and this information was used in the descriptions of the performance results for each facility presented in Section VI.

Alternative Technologies Methodology

In addition to the demonstration of alternative chemical product systems, the DfE Printing Project evaluated the performance of two alternative screen reclamation technologies. These substitute processes rely on specialized equipment, and were, therefore, not demonstrated at SPTF. Instead, the observers travelled to facilities where the equipment was available and evaluated the processes using criteria similar to those used by SPTF during their tests of the alternative chemicals. The two technologies demonstrated were: (1) a high pressure water blaster; and (2) a sodium bicarbonate reclaim system.

For both of these evaluations, an observer brought three imaged screens to the demonstration site. Once on-site, the observer applied ink to each screen. Solvent-based ink was applied to one screen, UV ink to another, and water-based ink was applied to the third screen. The alternative technology was then used to reclaim each of the screens and the observer recorded the same data as was recorded for the alternative chemical systems. For the high pressure water blaster technology, testing was conducted at a printing facility that was already using the required equipment in production. For the sodium bicarbonate technology, the evaluations were done at the equipment manufacturer's facility, since it is still a developing technology and is not in use at any printing facilities.

COSTING METHODOLOGY

In general, the cost estimate for each reclamation method was composed of the sum of four distinct cost elements: labor, reclamation products, materials, and waste disposal.

Labor

The printer's staff time spent on each reclamation step (e.g., ink removal, emulsion removal, haze removal) was collected or estimated from various sources. The total time estimate does not include collecting screens from printing areas, waiting for product reactions as might be specified in the manufacturers's application instructions, maintenance of reclamation area, or handling of segregated waste materials. The labor cost was calculated as the total time spent multiplied by (1) the average wage rate for screen reclaimers of $6.53/hour (as reported in SPAI's 1993 Wage Survey Report for the Screen Printing Industry) and (2) an industry multiplier of 2.01 (calculated from SPAI's 1992 Operating Ratios Study) to account for fringe and overhead costs.

Reclamation Products

The average usage per screen was calculated for each product (i.e., ink remover, emulsion remover, haze remover) used by a particular facility. Because of wide variations, no attempt was made to average across facilities or product systems. For comparative purposes, "normalized" average quantities were calculated by multiplying actual usage with the ratio of the baseline screen of 2,127 in^2 to the recorded screen size. Multiplying usage with the unit cost of each product (provided by each participating manufacturer and summarized in Table 3.1) yielded the reclamation product costs. Costs associated with special storage requirements for products were not considered in the cost analysis.

TABLE 3.1

ALTERNATIVE RECLAMATION SYSTEMS: MANUFACTURER PRICING

Product System	Ink Remover	Emulsion Remover	Haze Remover
Alpha	$18.20/gallon ($850/55 gallons)	$4.00/gallon	$10/kg
Beta	$15.10/gallon	Ink remover only	Ink remover only
Chi	$31.20/gallon ($1,315/55 gallons)	$32.00/gallon ($438/15 gallons) ($1,238/55 gallons)	$31.20/gallon ($1,315/55 gallons)
Delta	$20.00/gallon ($900/55 gallons)	$32.00/gallon ($438/15 gallons) ($1,238/55 gallons)	$20.00/gallon ($900/55 gallons)
Epsilon	$7.80/gallon	$29.80/kg	$2.40/kg
Gamma	$11.00/gallon (25 liters/$72)	$3.50/kg	$10.40/gallon (25 liters/$62)
Mu	$7.80/gallon (20 liters/$41)	$10.40/gallon (3 five liter units/$41)	$37.80/gallon (5 five liter units/$50)
Phi	$24.95/gallon	$24.95/gallon	$39.95/gallon
Omicron	$13.40/gallon ($540/55 gallons)	$11.00/gallon ($530/55 gallons)	No haze remover Degreaser costs: $10/gallon ($500/55 gallons)
Theta	No ink remover costs Other costs: $5,170	$21.95/gallon	$43.00/gallon
Zeta	$23.00/gallon	$23.00/gallon	$30.00/gallon

Materials (e.g., rags, screens)

Rag use was estimated or recorded for the baseline and all substitute products. It was assumed that rags were leased and laundered at a cost of $0.15/rag. Changes in the number of application brushes between the baseline and substitute methods is considered inconsequential.

Waste Disposal

Hazardous waste disposal costs were assumed only if the reclamation products contain RCRA-listed chemicals or if the products are defined as characteristic wastes due to their ignitable nature (see Table 3.2). For each product system, hazardous waste generation rates (in g/day for 6 screens), were estimated by chemical engineers on EPA's staff. This methodology does not consider the possible effect residual inks may have on the waste's hazard classification. It also assumes that other wastestreams at the facility are hazardous; thus, the labor cost of training and managing hazardous wastes is not associated with screen reclamation only. Given that filtration systems used to remove residual inks and reclamation products from spent wash water (spent filters must be disposed of) may be required for both baseline and alternative analysis. The analysis focuses on quantifying cost differences among reclamation methods.

TABLE 3.2

DETERMINATION OF RCRA HAZARDOUS WASTE LISTING

Product System	Ink Remover	Emulsion Remover	Haze Remover
Alpha	RCRA characteristic waste (ignitable) Flashpoint - 101°F/38°C	None	None
Beta	None	Ink remover only	Ink remover only
Chi	None	None	None
Delta	None	None	None
Epsilon	RCRA Listed waste (cyclohexanone - all other components qualify as listed under mixture rule). Also Characteristic waste (ignitable) Flashpoint = 46°C/115°F	None	1:1 dilution with ink remover. All components qualify as hazardous waste under mixture rule.
Gamma	None	None	None
Mu	RCRA Characteristic waste (ignitable) Flashpoint = 131°F/55°C	None	None
Phi	None	None	None
Omicron (AE & AF)	None	None	None
Theta	No ink remover	None	RCRA Listed waste (cyclohexanone - all other components qualify as listed under mixture rule)
Zeta	RCRA Characteristic waste (ignitable) Flashpoint = 101°F/38°C	None	None

All information on flashpoint was gathered from masked MSDSs submitted by supplier. None of the above information should be used for compliance purposes. None of the chemicals in these formulations is listed as toxic characteristic contaminants and were not treated as such in the cost analysis; however, printers should use the Toxicity Characteristic Leaching Procedure (TCLP) to determine the applicability of the toxicity characteristic to their particular waste stream.

SECTION IV

CHARACTERIZATION OF PARTICIPATING FACILITIES

PRODUCTS PRINTED

The cooperation of the volunteer printing facilities was essential in obtaining the performance data for this project. The participating printers were not intended to be representative of the screen printing industry as a whole. They were, however, fairly typical in the type of products produced. The DfE project did limit participation to facilities using plastic and vinyl substrates to reduce one source of variability. Most of the participating printers also printed on other media, such as paper, metal, glass, or ceramics.

The screen printing industry in the United States can be divided into three major types of facilities:

- **Commercial screen printers:** Commercial operations print garments, signs, posters, decals, and banners for commercial applications, commercial screen printing shops are assumed to be the most prevalent in the industry.
- **Industrial screen printers:** Industrial screen printers print front panels, circuits, glassware, and labels for original equipment.
- **In-plant screen printers:** Many manufacturing facilities have in-house screen printing departments that are dedicated to printing markings or decals for the parts produced in that facility. Although they operate screen printing equipment, their primary business is not screen printing, and they do not classify themselves as screen printers.

The majority of the printers participating in the DfE Printing Project were commercial screen printers. Because the in-plant screen printers are typically classified by the products they produce, not by the processes they use to produce those products, it is difficult to quantify the size of the screen printing industry in the United States. SPAI estimates that there are at least 40,000 plants in the U.S. with screen presses, not including in-plant operations or the majority of industrial screen printing operations. The 1990 SPAI survey of the industry estimated that 55 percent of commercial screen printers print on textiles. Graphic arts printing is another major category in commercial screen printing and it includes such diverse products as point-of-purchase displays, posters, decals, and banners. The types of products printed by the volunteer facilities is just as diverse as the range for the industry as a whole. The most common products of the participating facilities includes labels, store displays, decals, panels, graphic overlays, nameplates, banners, signs, and fleet graphics.

SIZE OF FACILITIES

Approximately 90 percent of the volunteer facilities had less than 50 employees, which is consistent with the 1992 Screen Printing magazine survey which found that 86 percent of the screen printing facilities had fewer than 50 employees. Unlike the national averages, however, the number of participating shops with less than 20 employees (47 percent) was almost the same as the number of shops with 21 to 50 employees (42 percent). Nationally, approximately 71 percent of the facilities have less than 20 employees, while only 14 percent have 21 to 50 workers. Table 4.1 compares the number of screen printing employees per facility nationwide (data from the 1992 Screen Printing magazine survey) to the number of employees in the volunteer facilities.

TABLE 4.1

NUMBER OF EMPLOYEES IN SCREEN PRINTING FACILITIES

Number of Employees	% of Facilities Nationwide	% of Volunteer DfE Facilities
1 - 20	71.5%	47%
21 - 50	14.0%	42%
51 - 100	7.8%	11%
More than 100	7.4%	0%

ACCEPTANCE OF ALTERNATIVE PRODUCTS

The attitudes of the participating facilities' staff towards the adoption of alternative screen reclamation products is most likely not reflective of the industry as a whole. All demonstration plants were members of SPAI and they volunteered their facility and their time to participate in this project. Their willingness to change their procedures in order to identify environmentally preferable products for their own facilities and for other printers shows a commitment that may not be representative of the industry. This is borne out by the fact that many of the facilities invested considerable time experimenting with different application techniques to achieve optimal performance from the alternative products. Although all facilities volunteered to participate for the full month-long demonstration, some facilities discontinued product use prematurely because of changes in their personnel and production schedules, or because of poor product performance.

SECTION V

CHARACTERIZATION OF PRODUCTS DEMONSTRATED

ALTERNATIVE PRODUCT SYSTEM SUBMITTAL PROCEDURE

Manufacturers' cooperation in this project was essential to gather performance information on as many alternative product systems as possible at the start of the project. The DfE project staff contacted all known manufacturers of screen reclamation products designed for printers who use vinyl or plastic substrates, and invited them to submit alternative product systems. In addition to directly contacting manufacturers, the DfE project team also encouraged product submittals through articles in trade magazines and announcements at the annual SPAI convention and trade show. This is due, in part, to the expectation that impending regulations may effect market availability and use of these substances. The DfE Project Staff did not solicit those products containing chlorinated compounds due to the scheduled phase-out of many of these chemicals under the 1990 Clean Air Act Amendments.

Prior to submitting their products, manufacturers were informed that product trade names would be masked throughout the demonstrations. Neither the volunteer printers nor the DfE observers would know the manufacturer of the products being evaluated. Trade names are not listed in the CTSA document or in this report. Product systems are only identified by a generic formulation: a list of the chemical components associated with each individual product (the ink remover, the emulsion remover, and the haze remover). These formulations are presented in Section VI in tables 6.1 and 6.2.

SECTION VI

PERFORMANCE AND COST RESULTS

EXPLANATION OF VARIABILITY IN RESULTS

This section describes the product systems' performance during the demonstration project and the cost of each alternative system compared to a baseline system. For each system, a description of the demonstration facilities is followed by the results from the evaluation at SPTF, the details of performance at the volunteer printing facilities, and the costs for each volunteer facility to switch from a baseline system to the system demonstrated at their plants. A table is also included for each product system which provides summary statistics from the performance and cost of the system.

The information summarized in this section comes from five sources:

- SPTF evaluations where screens with different ink types (up to three types: solvent-based, UV-cured, and water-based) were reclaimed with the alternative product system;
- Facility Background Questionnaires profiling printing and reclamation operations of each site;
- DfE Observers Evaluation Sheets where the observer recorded information on one reclamation with the current product system and up to three reclamations using the alternative product system;
- Printers Evaluation Sheets where the facility employees completed as many as 12 observation forms per week for four weeks; and
- Logs of the weekly follow-up calls made to each facility by the DfE observers.

Performance demonstrations were not scientifically rigorous but were subjective assessments which reflected the conditions and experiences of the employees at two or three individual facilities. As the printers involved in this project pointed out, the specific parameters of a print run can influence product performance significantly. In several cases, two facilities with similar operating parameters using the same reclamation products had very different perceptions of the product performance. Among the reasons why the results of performance demonstrations for one particular product system may differ from one facility to another and/or from the SPTF results are:

- **Variability of screen conditions.** Because performance demonstrations were carried out during production runs, many factors which affect the performance of reclamation products were not controlled during the performance demonstrations including: age of screen, ink color, ink coverage, image size, ink type and drying time prior to reclamation.

• **Variability of ambient conditions.** Conditions, such as temperature, humidity, and ventilation were recorded but not controlled during performance demonstrations. Many screen printers reported that ambient conditions affect performance of the products they use (e.g., temperature and humidity effect on drying of ink on screens).

• **Chemical interactions with products used previously on the screen.** Printers and manufacturers have reported that chemicals previously applied to clean a screen can affect the performance of products currently used to clean the screen. Product systems are often designed for chemical compatibility during the screen reclamation process; if another product is added to the product system that is chemically incompatible, cleaning performance of the system may be affected. For example, if a printer who has been using a variety of hydrocarbon solvents, such as acetone and xylene for screen cleaning, switches to an alternative product to clean the screen, the performance of the alternative system may be affected by a residue of hydrocarbons on the surface of the screen. Testing may have been more effective if a new screen was used, however, this was typically not the case in the performance demonstration. In either case, the performance demonstration may have been affected by (1) residue chemicals on the surface of the screen or (2) the chemical "conditioning" of the screen.

• **Variability of staff involved in performance demonstrations.** During laboratory testing, the same technician conducted all tests and recorded the results. At the volunteer facilities, several different individuals often conducted the reclamations and recorded the data. Reclaimers' past experience also differs and can affect their perception of performance. For example, a screen reclaimer who has only used highly effective, and sometimes hazardous, ink removers may differ in their opinion of "moderate scrubbing effort" from a reclaimer whose current ink remover instructions call for several minutes of scrubbing with a brush.

• **Level of cleanliness expected by the facility.** The DfE observers found that different facilities could have very different opinions about the cleanliness of a screen. At some facilities, a light haze is acceptable and it does not affect the quality of future prints. Other facilities may require that every screen look new after reclamation.

Where possible, the text summaries of product system performance in this section point out where these factors may have contributed to disparate results among facilities evaluating the same product system.

The inclusion of widely variable conditions across and within facilities and the short duration of the performance demonstrations did not allow the results to be interpreted as definitive performance assessments of the product systems. In addition, some facilities did not provide the full complement of observation forms for several reasons including: unacceptable performance of the product system, personnel problems, insufficient volume of products supplied, and, in one case, lost records of the performance demonstrations. Based on the forms that were completed by the printers during the four week demonstration, analyses were prepared for each product system, keeping each facilities' experiences with that product system separate. A number of statistics correlations were attempted for each facility but the results are not statistically significant due to small sample size. Correlations included:

- the effectiveness of ink removal compared with variables such as effort/time spent on ink removal, ink color, number of impressions
- the condition of screen after emulsion removal step compared with variables such as effort/time spent on emulsion removal, prior ink coverage
- the condition of screen after all reclamation steps are complete compared with effort/time spent on haze removal, effectiveness of previous steps

Where appropriate, these results are included within the text summaries of each product system. Summary statistics, such as average amount of product used, are presented in accompanying tables.

PRODUCT SYSTEM CHEMICAL FORMULATIONS

One of the goals of this project is to encourage printers to use risk and hazard information to make more informed, environmentally-sound decisions about the chemicals and processes they use. To accomplish this goal, Tables 6.1 and 6.2 provide printers with the chemical formulations of the product systems demonstrated. Since product trade names are not given, the printer must identify the products by their chemical class. The first table (Table 6.1) lists the formulation of each product system in generic chemical categories. The second table (Table 6.2) describes the chemicals which are included in each generic classification. Using the chemical composition information in conjunction with the performance summaries, printers can determine which product system(s) they think would be successful in their facility. Once that determination is made, printers can contact their distributors, inform them of the type of product they are looking for (based on the chemical formulation), and ask for a recommendation on such a product system. A list of the participating manufacturers is given in Appendix H of this report. The list includes telephone numbers and contact names so printers can also directly contact these manufacturers if they prefer.

In making a decision on which products to try, the printer can evaluate the laboratory results, the field demonstration data, and the cost summaries. For more information on the risks associated with each product system, the printer should refer to the EPA's CTSA Screen Reclamation document. These products are referred to as "alternatives," however, a printer can only evaluate the relative human health risks and the environmental impacts of these products by reviewing the health and environmental risk information presented in the CTSA.

TABLE 6.1

CHEMICAL COMPOSITION OF ALTERNATIVE SCREEN RECLAMATION SYSTEMS

Product System	Ink Remover	Emulsion Remover	Haze Remover
Alpha	Aromatic solvent naphtha Propylene glycol series ethers	Sodium periodate Water	Alkali/caustic Tetrahydrofurfuryl alcohol Water
Beta	2-octadecanamine, N,N-dimethyl-,N-oxide or a modified amine from unsaturated soy bean oil fatty acid Water	Ink remover only	Ink remover only
Chi	Diethylene glycol series ethers Propylene glycol series ethers N-methyl pyrrolidone Ethoxylated nonylphenol	Sodium periodate Water	Diethylene glycol series ethers Propylene glycol series ethers N-methyl pyrrolidone Ethoxylated nonylphenol
Delta	Dibasic esters Propylene glycol series ethers Ethoxylated nonylphenol	Sodium periodate Water	Dibasic esters Propylene glycol series ethers Ethoxylated nonylphenol
Epsilon	Cyclohexanone Methoxypropanol acetate Diethylene glycol Benzyl alcohol Diacetone alcohol Aromatic solvent naphtha Derivatized plant oil	Sodium periodate Sulfate salt Water	Alkyl benzene sulfonates Ethoxylated nonylphenol Phosphate salt Sodium hydroxide Derivatized plant oil Water
Gamma	Tripropylene glycol methyl ether Diethylene glycol butyl ether acetate Dibasic esters Fatty alcohol ethers Derivatized plant oil	Sodium periodate Sulfate salt Phosphate salt Other Water	Sodium hypochlorite Alkali/caustic Sodium alkyl sulfonate Water
Mu	Dibasic esters Methoxypropanol acetate d-Limonene Ethoxylated nonylphenol Derivatized plant oil	Periodic acid Water	Sodium hypochlorite Alkali/caustic Sodium alkyl sulfonate Water

(continued)

TABLE 6.1 (continued)

Product System	Ink Remover	Emulsion Remover	Haze Remover
Phi	Dibasic esters	Sodium periodate Water Ethoxylated nonylphenol Other	N-methyl pyrrolidone Dibasic esters
Omicron (AE)	Diethylene glycol butyl ether Propylene glycol	Sodium periodate Ethoxylated nonylphenol Water	Ethoxylated nonylphenol Phosphate surfactant Other Water
Omicron (AF)	Diethylene glycol butyl ether Propylene glycol	Sodium periodate Ethoxylated nonylphenol Water	Ethoxylated nonylphenol Phosphate surfactant Alkali/caustic Other Water
Theta	None	Sodium periodate Water	Alkali/caustic Cyclohexanone Furfuryl alcohol
Zeta	Propylene glycol series ethers	Sodium periodate Water	Alkali/caustic Propylene glycol Water

TABLE 6.2

CATEGORIZATION OF SCREEN RECLAMATION CHEMICALS FOR USE IN ALTERNATIVE PRODUCT SYSTEM FORMULATIONS

Category	Chemicals in Category
Alkali/caustic	Sodium hydroxide Potassium hydroxide
Alkyl benzyl sulfonates	Dodecyl benzene sulfonic acid, triethanol amine salt Sodium salt, dodecyl benzene sulfonic acid
Aromatic solvent naphtha	Solvent naphtha (petroleum), light aromatic Solvent naphtha (petroleum), heavy aromatic
Derivatized plant oil	Tall oil, special Ethoxylated castor oil
Dibasic esters	Diethyl adipate Diethyl glutarate Diisopropyl adipate Dimethyl adipate Dimethyl glutarate Dimethyl succinate
Diethylene glycol series ethers	Diethylene glycol butyl ether Diethylene glycol butyl ether acetate
Fatty alcohol ethers	Alcohols, C_8 - C_{10}, ethoxylated Alcohols, C_{12} - C_{14}, ethoxylated
Phosphate salt	Sodium hexametaphosphate Trisodium phosphate
Propylene glycol series ethers	Dipropylene glycol methyl ether Propylene glycol methyl ether Tripropylene glycol methyl ether Propylene glycol methyl ether acetate Dipropylene glycol methyl ether acetate Ethoxypropanol Ethoxypropyl acetate Methoxypropanol acetate

BASELINE SCREEN RECLAMATION

The system used to estimate baseline costs was selected as it was assumed to be representative of systems currently in use. The baseline products used are:

Ink remover	=	lacquer thinner consisting of:	30% methyl ethyl ketone
			20% naphtha, light aliphatic
			20% toluene
			15% n-butyl acetate
			10% isobutyl isobutynate
			5% methanol
Emulsion remover	=	1.25% sodium periodate in water	
Haze remover	=	10% xylene (by weight)	
		30% acetone	
		30% mineral spirits	
		30% cyclohexanone	

For ink remover, time and volume information was taken from SPTF testing. An average price for lacquer thinner was calculated from prices reported in the Workplace Practices Questionnaire conducted by SPAI and the University of Tennessee. Time, volume, and price information for baseline emulsion removal was taken from the Zeta system used in performance demonstrations. Time and volume information for the four-chemical baseline haze remover was not available from the performance demonstrations, and had to be estimated based on the SPTF evaluation of similar haze remover, resulting in a time of 11.5 minutes. A volume of 3 ounces for haze removal was taken from the application instructions developed for SPTF. A price for purchasing this formulation in a 55-gallon drum quantity was quoted by Ashland Chemical.

PRODUCT SYSTEM ALPHA

For Product System Alpha, this section describes the performance results from the laboratory performance tests and from the volunteer facility demonstrations, and also presents two tables: one summarizes the performance results and the other presents costing data. For information on the operating conditions of the three volunteer printing facilities where Product System Alpha was demonstrated, or on the specific details of the product system performance at each of the facilities, see Appendix I.

Product System Alpha consisted of an ink remover, emulsion remover, and a haze remover. The products were demonstrated at Facilities 8, 13, and 14. Facility 8 prints labels, nameplates, and graphic overlays. They reclaimed 48 screens over 4 weeks of demonstrations using solvent-based inks and an indirect emulsion. Facility 13 prints store displays, decals, and outdoor signs, and they reclaimed 13 screens using UV-cured and solvent-based inks and a direct photo stencil during the 2 weeks they participated in the demonstrations. Facility 14 prints metal nameplates, vinyl pressure sensitive decals, and signs. They used solvent-based inks and a direct photo stencil during the three weeks they used Product System Alpha to reclaim 36 screens.

Performance in the Laboratory

Product System Alpha was tested at SPTF on two screens (one with a solvent-based ink, and one with a UV-cured ink). This product system is not recommended for use with water-based inks. Performance of the product system was similar for both ink systems.

To apply the ink remover, the manufacturer recommends spraying the product on the screen, and wiping up the dissolved ink and solvent with an absorbent rag or cloth until the ink is removed. On the screen with the solvent-based ink, the ink dissolved well with moderate scrubbing. On the screen with the UV ink, the ink dissolved more easily and minimal scrubbing was needed. Four wipes were used to clean each screen. The technician noted that the ink remover had an unpleasant odor.

On both screens, the emulsion remover dissolved the stencil with moderate scrubbing effort, leaving no emulsion stain. There was a moderate ink stain remaining on the solvent-based ink screen after emulsion removal, but the application of the haze remover removed the stain completely. On the screen with UV ink, a light stain remained after emulsion remover use, but the haze remover lightened the stain considerably.

The standard ink remover used at facility 13 is a proprietary blend consisting primarily of tripropylene glycol methyl ether. Their emulsion remover consists primarily of sodium periodate. Haze remover is used as needed (on approximately 50% of the screens reclaimed). Information on the chemical composition of haze remover was not available. Using their standard product, ink is removed from the screen with a pressure wash, whereas rags are used to wipe off the ink when using the alternative ink remover. The application procedure for the alternative emulsion and haze remover products are very similar to this facility's standard application method.

Summary of Performance at the Volunteer Facilities

This section summarizes the product system performance as recorded by the printers using the products at all three of the demonstration facilities. The table at the end of the section summarizes both the field demonstration performance data and the results of the product tests performed at SPTF.

Ink Remover: Facility 8 reported that the ink remover worked well most of the time, but results were inconsistent and some extra scrubbing was required to achieve the desired results. Performance was improved if the ink remover was sprayed on both the scrubbing rag and the screen. The ink remover did not seem to work at all with epoxy inks. Facility 13 also reported that the ink remover required more time and scrubbing than their usual product. Facility 14 reported that the ink remover worked as well as their usual product. One screen reclamation employee at this facility reported that the ink remover worked particularly well with their vinyl inks.

Emulsion Remover: At Facility 8, the emulsion remover worked satisfactorily only if the screen was rinsed with hot water before applying the product. Facility 13 reported that the emulsion remover did not work as efficiently as their usual product, taking more time to dissolve the stencil and more scrubbing, even at full strength. Facility 14 reported that the emulsion remover worked as well as their usual product and required less effort than the regular product with the same positive results. The only negative feature mentioned by Facility 14 was that the emulsion remover left a slight green tint on the screen, but this tint was removed by the alternative haze remover.

Haze Remover: The haze remover performance varied between the three facilities. At Facility 8, the haze remover removed the ink stain on most of the screens, however, it did not sufficiently remove haze from about 20% of the screens. These screens had to be cleaned again with their standard product. Facility 13 thought that the haze remover did not work at all, and required extra scrubbing and follow up use with their regular product. Facility 14 initially reported that the haze remover performance was average, but another reclaimer said that it did not work as well as their usual product.

TABLE 6.3: PRODUCT SYSTEM ALPHA PERFORMANCE

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
In-field Demonstrations at Volunteer Printing Facilities							
Facility 8 *Solvent-based vinyl and epoxy inks*	*Ink remover*	10.8 ± 17.6 hrs (n=50)	1.7 ± 0.8 oz. (n=50)	5.9 ± 2.5 mins (n=32)	Moderate	Good on 40% of screens; Fair on 22%; Poor on 38%	• 20% of screens required additional cleaning before reusing them. • Needed to use hot water to get the emulsion to break down.
	Emulsion Remover	1.8 ± 4.2 mins (n=50)	1.0 ± 0.2 oz. (n=50)	9.0 ± 3.9 mins (n=50)	Moderate	With hot water, removed stencil.	
Average screen size = 823 in²	*Haze Remover*	1.1 ± 3.5 mins (n=50)	1.0 ± 0.0 oz. (n=39)	7.6 ± 2.5 mins (n=39)	Moderate	Haze was not removed from 20% of screens.	
Facility 13 *UV-curable and Solvent-based inks*	*Ink Remover*	1.5 ± 3.0 hrs (n=15)	2.5 ± 0.8 oz. (n=15)	15.5 ± 8.0 mins (n=15)	Moderate	Removed the ink but required extra time and effort.	• Most screens had to be re-cleaned with the standard haze remover before the could be reused.
	Emulsion Remover	5.7 ± 5.8 mins (n=6)	3.9 ± 2.0 oz. (n=7)	11.7 ± 4.5 mins (n=7)	Moderate	Removed stencil, but required extra time and effort.	
Average screen size = 1591 in²	*Haze Remover*	5.7 ± 4.0 mins (n=3)	1.3 ± 0.5 oz. (n=4)	9.5 ± 2.4 mins (n=4)	Moderate	Did not effectively remove the haze.	
Facility 14 *Solvent-based inks*	*Ink Remover*	6.6 ± 39.4 hrs (n=37)	4.4 ± 2.0 oz. (n=37)	5.0 mins (n=1)	Low/ Moderate (n=37)	Worked very well with vinyl ink; acceptable on other inks by increasing the soaking time.	• Most screens could be reused, however, some had to be recleaned with other products. • Two reclaimers felt the haze remover performance was acceptable, one did not.
	Emulsion Remover	19.9 ± 17.9 hrs (n=37)	4.1 ± 0.7 oz. (n=37)	5.0 ± 0.0 mins (n=36)	Low (n=37)	Removed stencil easily.	
Average screen size = 1577 in²	*Haze Remover*	5.0 ± 19.6 mins (n=37)	4.0 ± 1.0 oz. (n=15)	5.2 ± 0.8 mins (n=16)	Moderate (n=14)	Haze remaining on some screens had to be removed with their standard product.	

(continued)

TABLE 6.3 (continued)

Laboratory Testing at SPTF						
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.5 oz.	3.9 mins	Moderate	Ink dissolved with scrubbing; has bad odor.
	Emulsion Remover	24 hours	1.0 oz.	3.7 mins	Moderate	Stencil dissolved completely; medium ink stain.
	Haze Remover	0 mins	1.0 oz.	9.7 mins	Low	Removed stain completely.
SPTF UV-curable Ink	*Ink Remover*	15 mins	2.0 oz.	3.5 mins	Low	Ink dissolved well; has bad odor.
	Emulsion Remover	24 hours	1.0 oz.	2.6 mins	Moderate	Stencil dissolved completely; medium ink stain remaining.
	Haze Remover	0 mins	1.0 oz.	10.0 mins	Low	Lightened ink stain.

TABLE 6.4

COST ANALYSIS FOR SYSTEM ALPHA

Description		Baseline	Alternative System Alpha		
			Facility 8	Facility 13	Facility 14
Facility Characteristics					
Average screen size (in^2)		2,127	823	1,591	1,577
Average # screens/day		6	12.5	20	12
Cost Elements per Screen					
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	22.5	36.7	15.3
	Cost ($)	$5.33	4.92	8.02	3.34
Materials and Equipment	# of rags used	3	1.1	4.1	0
	Cost ($)	$0.45	0.17	0.61	0
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	1.8	2.5	4.4
	Cost ($)	$0.22	0.21	0.31	0.53
	Emulsion Remover Average Volume (oz.)	3.5	1.0	3.9	4.1
	Cost ($)	$0.13	<0.01	0.01	0.01
	Haze Remover Average Volume (oz.)	3.0	1.0	1.3	4.0
	Cost ($)	$0.12	0.30	0.37	1.18
Hazardous Waste Disposal	Amount (g)	34	31	60	59
	Cost ($)	$0.02	0.02	0.04	0.04
Totals					
Total Cost/Screen		$6.27	5.62	9.36	5.10
Normalized*		$6.27	6.79	9.37	5.92
Total Cost/year		$9,399	17,574	46,800	15,313
Normalized*		$9,399	10,183	14,062	8,886

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

PRODUCT BETA

For Alternative Product Beta, this section describes the performance results from the laboratory performance tests and from the volunteer facility demonstration, and also presents two tables: one summarizes the performance results and the other presents costing data. For information on the operating conditions of the volunteer printing facility where Alternative Product Beta was demonstrated, see Appendix I.

Facility 12 used ink remover Beta during the performance demonstrations. Unlike the product systems submitted by other manufacturers, the manufacturer of Beta supplied the ink remover only. The facility used the alternative ink remover Beta, along with their standard emulsion remover and haze remover to reclaim their screens. During the demonstrations, the performance of ink remover Beta was recorded for 17 screens with solvent-based inks and a capillary film emulsion over a three week period. Facility 12 prints graphic overlays, labels, and flexible membrane switches, and all products are primarily printed on plastics.

Ink remover Beta was also sent to two other facilities who were not able to participate in the Performance Demonstrations. One facility could not use the product because they send all their screens out to be reclaimed; they only use ink removers as an in-process cleaner. Since this project is intended to evaluate ink removers used for screen reclamation, not for in-process ink removal, this facility did not participate. The second facility felt they could not use the alternative products because of an on-going EPA inspection. The printer regretted not being able to participate, however, the EPA was in the process of testing his waste water, so he did not want to add any new chemicals to his waste stream.

Performance in the Laboratory

Ink remover Beta was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-cured ink, and one with a water-based ink). The manufacturer recommended removing the ink by spraying the product directly onto the screen and wiping off the ink with a clean rag. On all three screens, the technician reported that the ink dissolved well, however a fair amount of wiping was required. For the screen with the solvent-based ink, seven wipes were needed. Six wipes were used on the UV ink screen, and eight wipes were required to remove the ink from the water-based ink screen. The technician noticed that the ink remover affected the stencil image in the half tone area on all screens. The color of the stencil appeared on the rag, which also indicated that the product was deteriorating the emulsion.

Performance at the Volunteer Facility

This section summarizes the product system performance as recorded by the printer using the alternative product Beta at the demonstration facility. The table at the end of the section summarizes both the field demonstration performance data and the results of the product tests performed at SPTF.

Facility 12 felt the ink remover Beta sufficiently removed the ink from most screens, however, it took a long time to remove the ink and the product left an oily haze on the screen. In some cases, they reported ink residue or ink stains were also left in the mesh. The oily film and the ink residue were both removed during emulsion removal and haze removal steps, and all screens were reusable for all types of printing jobs.

Unlike all of the other facilities in the Performance Demonstrations, an observer did not visit this facility to introduce them to the project and to the alternative product. This lack of in-person guidance may have affected the results. During the first week, the printer sprayed on the ink remover, rubbed it in with a brush and pressure washed the screen to remove the ink. This application method was very messy and did not effectively remove the ink. For the remainder of the demonstrations, the printer changed his application method and used rags to wipe the ink off the screen. This second method removed the ink much more easily, but took it took a long time (an average of 25 minutes per screen). Two or three rags were used on each screen. While wiping the screen with the rags, the printer noticed that the emulsion started to deteriorate. He also mentioned that he needed to replace his filters on the ink removal sink waste water more frequently when using the alternative product.

In reviewing the data, there did not appear to be any correlations between the product performance and the screen conditions, however, the printer felt it was much easier to remove wet ink and light colored inks, than dried on and black ink.

TABLE 6.5: PRODUCT BETA PERFORMANCE

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
In-field Demonstrations at Volunteer Printing Facilities							
Facility 12							
Solvent-based ink *Average screen size = 1089 in^2*	*Ink remover*	3.9 ± 8.2 hrs (n=15)	4.2 ± 1.5 oz. (n=17)	24.6 ± 5.4 mins (n=17)	Moderate	Removed ink but took a long time and left an oily residue.	• Not demonstrated as part of a system.
Laboratory Testing at SPTF							
SPTF Solvent-based Ink	*Ink Remover*	15 mins	2.5 oz.	9.1 mins	Moderate	Ink dissolved well, but 7 rags were needed and the stencil started to deteriorate.	
SPTF UV-curable Ink	*Ink Remover*	15 mins	2.5 oz.	6.3 mins	Moderate	Ink dissolved well, but 6 rags were needed and the stencil started to deteriorate.	
SPTF Water-based Ink	*Ink Remover*	15 mins	3.0 oz.	12.0 mins	Moderate	Ink dissolved well, but it took a long time (8 rags were needed) and the stencil started to deteriorate.	

TABLE 6.6

COST ANALYSIS FOR ALTERNATIVE BETA

Description		Baseline (Without Haze Remover)	Alternative System Beta** Facility 12
Facility Characteristics			
Average screen size (in^2)		2,127	1,089
Average # screens/day		6	15
Cost Elements per Screen			
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	12.9	29.4
	Cost ($)	$2.82	6.43
Materials and Equipment	# of rags used	3	2.2
	Cost ($)	$0.45	0.34
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	4.2
	Cost ($)	$0.22	0.50
	Emulsion Remover Average Volume (oz.)	3.5	1.8
	Cost ($)	$0.13	0.06
	Haze Remover Average Volume (oz.)	---	---
	Cost ($)	---	---
Hazardous Waste Disposal	Amount (g)	34	0
	Cost ($)	$0.02	0
Totals			
Total Cost/Screen		$3.63	17.33
Normalized*		$3.63	7.97
Total Cost/year		$5,446	27,477
Normalized*		$5,446	11,958

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

** The emulsion removal use and cost per screen were taken from performance demonstration results for product system Zeta.

PRODUCT SYSTEM CHI

For Product System Chi, this section describes the performance results from the laboratory performance tests and from the volunteer facility demonstrations, and also presents two tables: one summarizes the performance results and the other presents costing data. For information on the operating conditions of the two volunteer printing facilities where Product System Chi was demonstrated, or on the specific details of the product system performance at each of the facilities, see Appendix I.

Product System Chi consisted of an ink remover and an emulsion remover. In place of a separate haze remover product, the ink remover was reapplied to remove haze. A degreaser accompanied this product system and was used by the facilities, however, detailed information on the performance of the degreaser is not included in the scope of this project. The performance of the product system was demonstrated at Facilities 3 and 21. Facility 3 prints decals and vacuum formed sheets; Facility 21 prints decals for glass and ceramics. During the four week demonstration period, Facility 3 reclaimed 47 screens and Facility 21 reclaimed 48 screens. Both facilities used solvent-based inks during the demonstrations, and Facility 3 used a dual-cure emulsion, while Facility 21 used a capillary film emulsion.

Performance in the Laboratory

Product System Chi was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-cured ink, and one with a water-based ink). The ink remover performance varied, depending on the type of ink used. Performance of the emulsion remover and the haze remover was consistent for all three screens. All products were applied according to the manufacturer's recommended application procedure.

On the screen with the solvent-based ink, there was considerable ink residue remaining after spraying the screen with product, scrubbing with a brush, and rinsing with a high pressure wash. The technician also noticed that the stencil was beginning to peel off. After repeating the ink remover application process, the ink residue was still present and about half of the stencil had been removed. The ink dissolved more easily on the screen with UV ink, however, after using the ink remover, a gray haze remained on the screen, but there was no noticeable ink residue and the stencil was intact. On the screen with the water-based ink, the product dissolved the ink fairly well, however, a light ink residue remained on the screen and the stencil began to peel off.

The emulsion remover easily dissolved the stencil with only light scrubbing on all three screens, leaving no emulsion residue behind. On the screen with the solvent-based ink, the heavy ink residue was still present after using the emulsion remover. When additional ink remover was applied (used instead of a haze remover in this product system), it removed the residue and lightened the stain. After using the emulsion remover on the screen with UV ink, a moderate to heavy ink stain remained. The reapplication of the ink remover lightened this stain considerably. On the screen with water-based ink, the ink residue persisted in some areas and there was a heavy ink stain on the screen after using the emulsion remover. An additional application of ink remover lightened the stain, but did not remove it.

Summary of Performance at the Volunteer Facilities

This section summarizes the product system performance as recorded by the printers using the products at both of the demonstration facilities. The table at the end of the section summarizes both the field demonstration performance data and the results of the product tests performed at SPTF.

Ink Remover: The ink remover performance was considered satisfactory by Facility 3 and was considered good at Facility 21. At Facility 3, the alternative ink remover took longer to solubilize the ink and required more physical effort than their usual product. Facility 21 reported that the Product System Chi ink remover worked very well on most of their inks, but the alternative ink remover did not work as well with cover/flux ink or clear cover coats. They have similar problems with their standard ink remover on the cover/flux and clear coats. They also found additional scrubbing was needed when using the alternative ink remover on very coarse (low mesh count) screens. Overall, they described the ink remover performance as good, but not quite as good as their standard product.

Emulsion Remover: The two facilities were both quite pleased with the performance of the emulsion remover. Facility 3 reported the performance was as good as their standard product. Facility 21 thought that the emulsion remover worked much better than their usual product. Although it worked well on both direct and capillary film emulsions, Facility 21 found a little more effort was required to remove the capillary film emulsions than the direct emulsions.

Haze Remover: This system did not include a haze remover. Instead, the manufacturer recommended that the ink remover be used a second time as a haze remover. After using the ink remover following removal of the emulsion, Facility 3 reported that an image was still left on the screen and that, when used for haze removal, the ink remover did not perform as well as their usual haze remover. At Facility 21, a haze remover was needed on only one screen of the 48 screens reclaimed.

TABLE 6.7: PRODUCT SYSTEM CHI PERFORMANCE

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
In-field Demonstrations at Volunteer Printing Facilities							
Facility 3	*Ink remover*	7.2 ± 3.6 mins (n=50)	1.1 ± 0.4 oz. (n=50)	6.6 ± 2.3 mins (n=50)	Moderate	Dissolved ink with extra effort.	• All screens could be reused. • Printer was concerned with effect of possible haze build up over time.
Solvent-based ink	*Emulsion Remover*	15.1 ± 21.7 hrs (n=50)	2.1 ± 0.4 oz. (n=50)	2.9 ± 0.3 mins (n=50)	Low	Removed stencil easily.	
Average screen size = 1977 in²	*Haze Remover*	0.2 ± 0.2 mins (n=47)	2.1 ± 0.3 oz. (n=47)	2.9 ± 0.3 mins (n=47)	Low	Ghost images built up.	
Facility 21	*Ink Remover*	7.6 ± 12.6 hrs (n=51)	1.1 ± 0.3 oz. (n=48)	2.0 ± 1.5 mins (n=47)	Low	Dissolved ink with extra effort.	• All screens could be reused for future print jobs. • Haze removal step rarely needed. • Worked well on metallic inks.
Solvent-based ink	*Emulsion Remover*	4.7 ± 8.6 mins (n=51)	1.5 ± 1.4 oz. (n=48)	2.5 ± 2.2 mins (n=48)	Low	Removed stencil easily.	
Average screen size = 1088 in²	*Haze Remover*	15.0 mins (n=1)	2.0 oz. (n=1)	3.5 ± 0.7 mins (n=2)	Moderate	Several applications needed to remove haze.	
Laboratory Testing at SPTF							
SPTF Solvent-based Ink	*Ink Remover*	15 mins	not recorded	7.5 mins	Moderate	Heavy ink residue. Started to remove stencil.	
	Emulsion Remover	24 hours	1.0 oz.	3.3 mins	Low	Dissolved stencil easily. Heavy ink residue remaining.	
	Haze Remover	0 mins	2.5 oz.	4.7 mins	Low	Lightened ink stain.	
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.0 oz.	4.0 mins	Low	Dissolved the ink but left a grey haze over entire screen.	
	Emulsion Remover	24 hours	1.0 oz.	4.0 mins	Low	Dissolved stencil easily.	
	Haze Remover	0 mins	1.0 oz.	4.0 mins	Low	Lightened the ink stain.	
SPTF Water-based Ink	*Ink Remover*	15 mins	2.0 oz.	4.5 mins	Moderate	Light ink residue. Stencil started peeling.	
	Emulsion Remover	24 hours	1.5 oz.	4.1 mins	Low	Dissolved stencil easily. Heavy ink stain and light residue.	
	Haze Remover	0 mins	1.5 oz.	3.3 mins	Low	Lightened ink stain.	

TABLE 6.8

COST ANALYSIS FOR ALTERNATIVE CHI

Description		Baseline	Alternative System Chi: Facility 3	Alternative System Chi: Facility 21
Facility Characteristics				
Average screen size (in^2)		2,127	1,977	1,088
Average # screens/day		6	15	23
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	12.3	8.0
	Cost ($)	$5.33	$2.69	$1.74
Materials and Equipment	# of rags used	3	1.2	1.2
	Cost ($)	$0.45	0.18	0.19
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	1.1	1.1
	Cost ($)	$0.22	0.21	0.21
	Emulsion Remover Average Volume (oz.)	3.5	2.1	1.5
	Cost ($)	$0.13	0.07	0.05
	Haze Remover Average Volume (oz.)	3.0	2.1	2.0
	Cost ($)	$0.12	0.39	0.37
Hazardous Waste Disposal	Amount (g)	34	0	0
	Cost ($)	$0.02	0	0
Totals				
Total Cost/Screen		$6.27	3.55	2.56
Normalized*		$6.27	3.89	3.25
Total Cost/year		$9,399	13,312	14,413
Normalized*		$9,399	5,829	4,879

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

PRODUCT SYSTEM DELTA

For Product System Delta, this section describes the performance results from the laboratory performance tests and from the volunteer facility demonstrations, and also presents two tables: one summarizes the performance results and the other presents costing data. For information on the operating conditions of the two volunteer printing facilities where Product System Delta was demonstrated, or on the specific details of the product system performance at each of the facilities, see Appendix I.

Product System Delta was demonstrated at Facilities 10 and 11, who both used UV-cured inks. This product system consisted of an ink remover and an emulsion remover. In place of a separate haze remover product, the manufacturer recommended that the ink remover be reapplied to remove haze. A degreaser accompanied this product system and was used by the facilities, however, detailed information on the performance of the degreaser is not included in the scope of this project. Facility 10 prints store displays and Facility 11 prints vehicle markings and pressure sensitive decals. During the demonstrations, Facility 10 reclaimed 17 screens (all with dual-cure emulsion) over a 3 week period and Facility 11 reclaimed 31 screens (with a direct photo stencil) over 4 weeks.

Performance in the Laboratory

Product System Delta was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-cured ink, and one with a water-based ink). The ink remover performance varied, depending on the type of ink used. Performance of the emulsion remover and the haze remover was more consistent for the three screens. All products were applied according to the manufacturer's recommended application procedure. The ink remover was sprayed onto the screen and the ink was removed with a pressure rinse. The emulsion remover was also sprayed on and rinsed off at high pressure.

On the screen with the solvent-based ink, there was some ink residue remaining after applying the ink remover. While scrubbing the screen to remove the ink, approximately half of the emulsion was also removed. The results were similar on the screen with UV ink. Moderate ink residue remained on the screen and some of the stencil in the half-tone area peeled off while scrubbing. On the third screen (water-based ink), the ink residue was still heavy after applying the ink remover. Again, some of the stencil was lost while brushing in the ink remover. For this screen (water-based ink), the technician repeated the ink remover application process, which removed most of the residue, but also removed most of the stencil. Because two applications of ink remover were needed, the quantity of ink remover and the time it took to clean the screen were about twice as much for the screen with water-based ink.

The emulsion remover easily dissolved the stencil on all three screens, leaving no emulsion residue behind. On the screen with the solvent-based ink, a heavy ink residue was still present after using the emulsion remover. The haze remover, which is an additional application of the ink remover in this product system, was then applied. It removed the residue, but an ink stain remained on the screen. Some ink residue remained on the screen with UV ink after using the emulsion remover, but the haze remover (a second application of ink remover) removed the residue, leaving a moderate ink stain. The emulsion remover worked best on the screen with water-based ink. The stencil dissolved easily with only light scrubbing. A small amount of ink residue remained, as well as moderate ink stain. A reapplication of the ink remover removed the residue, but did not lighten the stain significantly.

Summary of Performance at the Volunteer Facilities

This section summarizes the product system performance as recorded by the printers using the products at both of the demonstration facilities. The table at the end of the section summarizes both the field demonstration performance data and the results of the product tests performed at SPTF.

Ink Remover: At Facility 10, the ink remover removed the ink efficiently on 67% of the screens. On the other 33% of the screens, a slight ink residue remained on the screen after using the ink remover. Overall, the performance of the ink remover was considered fair, however, it required extra effort and it had a strong smell and the screen reclamation employees thought it gave them headaches. Facility 11 had better results and they considered the performance of the ink remover to be very good. It consistently and efficiently removed the ink from their screens under most conditions.

Emulsion Remover: The emulsion remover worked very well and both facilities expressed an interest in continuing to use the product after the demonstrations were complete. Facility 10 found the product worked best when diluted at one part emulsion remover to one part water. Facility 11 used a dilution of one part emulsion remover to three parts water.

Haze Remover: Neither facility regularly documented the performance of the ink remover used in a second application as a haze remover. Facility 10 used it a few times and found that it did not remove the haze satisfactorily. On subsequent screens where a haze remover was needed, they used their standard haze remover product. At Facility 11, the ink remover and emulsion remover cleaned the screen well enough that a haze removal step was not needed.

TABLE 6.9: PRODUCT SYSTEM DELTA PERFORMANCE

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
In-field Demonstrations at Volunteer Printing Facilities							
Facility 10 UV-curable	*Ink remover*	17.4 ± 40.9 hr (n=18)	9.9 ± 4.2 oz. (n=18)	9.2 ± 2.1 mins (n=16)	Moderate	Removed ink well on 67% of screens; Slight residue on 33%.	• This facility used their own haze remover on most screens. • Ink remover performance was considered average.
Average screen size	*Emulsion Remover*	17.2 ± 32.7 hr (n=18)	8.6 ± 1.5 oz. (n=18)	4.7 ± 2.2 mins (n=18)	Moderate	Easily removed stencil.	
= 7767 in²	*Haze Remover*	3.0 mins (n=1)	1.0 oz. (n=1)	17.0 mins (n=1)	Moderate	Did not remove haze.	
Facility 11 UV-curable	*Ink remover*	11.4 ± 22.2 hr (n=30)	7.7 ± 3.5 oz. (n=29)	6.3 ± 3.3 mins (n=29)	Low/ Moderate	Consistently removed ink well.	• All screens were reusable. • Print image quality was excellent. • No haze remover needed.
Average screen size	*Emulsion Remover*	4.7 ± 14.4 min (n=31)	8.0 ± 3.5 oz. (n=30)	6.0 ± 3.2 mins (n=31)	Low/ Moderate	Easily removed stencil.	
= 5291 in²	*Haze Remover*	not needed	not needed	not needed	not needed	Not needed.	
Laboratory Testing at SPTF							
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.0 oz.	4.5 mins	Moderate	Moderate ink residue remaining; some stencil deterioration.	
	Emulsion Remover	24 hrs	1.5 oz.	3.7 mins	Moderate	Removed stencil completely. Ink residue remaining.	
	Haze Remover	0 mins	2.0 oz.	3.5 mins	Low	Removed residue; moderate ink stain left.	
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.0 oz.	3.5 mins	Moderate	Moderate ink residue remaining. Half of stencil peeled off.	
	Emulsion Remover	24 hrs	1.0 oz.	4.8 mins	Moderate	Removed stencil. Ink residue remaining.	
	Haze Remover	0 mins	1.5 oz.	2.5 mins	Low	Removed residue. Dark ink stain left.	
SPTF Water-based Ink	*Ink Remover*	15 mins	2.5 oz.	7.1 mins	Moderate	Slight ink residue remaining. Dissolved most of the stencil.	
	Emulsion Remover	24 hrs	1.0 oz.	3.8 mins	Low	Removed stencil completely. Slight ink residue and some ink stain remaining.	
	Haze Remover	0 mins	1.5 oz.	2.8 mins	Low	Removed residue. Slight ink stain left.	

TABLE 6.10

COST ANALYSIS FOR ALTERNATIVE DELTA

Description		Baseline	Alternative System Delta: Facility 11	Alternative System Delta: Facility 10
Facility Characteristics				
Average screen size (in^2)		2,127	5,292	7,767
Average # screens/day		6	5	8
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	12.3	30.9
	Cost ($)	$5.33	$2.69	$6.76
Materials and Equipment	# of rags used	3	0.0	6.5
	Cost ($)	$0.45	0.0	0.97
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	7.7	9.9
	Cost ($)	$0.22	0.99	1.27
	Emulsion Remover Average Volume (oz.)	3.5	8.0	8.6
	Cost ($)	$0.13	0.28	0.30
	Haze Remover Average Volume (oz.)	3.0	not used	1.0
	Cost ($)	$0.12	---	0.13
Hazardous Waste Disposal	Amount (g)	34	0	0
	Cost ($)	$0.02	0	0
Totals				
Total Cost/Screen		$6.27	3.96	9.43
Normalized*		$6.27	3.28	7.66
Total Cost/year		$9,399	4,953	17,675
Normalized*		$9,399	4,917	11,489

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

PRODUCT SYSTEM EPSILON

For Product System Epsilon, this section describes the performance results from the laboratory performance tests and from the volunteer facility demonstrations, and also presents two tables: one summarizes the performance results and the other presents costing data. For information on the operating conditions of the two volunteer printing facilities where Product System Epsilon was demonstrated, or on the specific details of the product system performance at each of the facilities, see Appendix I.

Product System Epsilon consisted of an ink remover, emulsion remover and haze remover. It's performance was demonstrated at Facility 20 and Facility 24. Facility 20 employs approximately 10 people and prints mainly banners and displays. Facility 24 employs 15 - 20 people in their production area with 4 employees involved in the screen printing operations of their business. They print pressure sensitive labels and Lexan face plates. Over a thirty-day period, Facility 20 reclaimed 48 screens and Facility 24 reclaimed 16 screens using Product System Epsilon. Both facilities used solvent-based inks, and Facility 24 also used UV-cured inks. Facility 20 used a dual-cured emulsion and Facility 24 used a direct photo stencil.

Performance in the Laboratory

Product System Epsilon was used at SPTF on three screens (one with a solvent-based ink, one with a UV-cured ink, and the third with water-based ink). Performance of the products varied depending on the ink type tested.

The ink remover dissolved the solvent-based ink well and was easy to use. A light grey haze was left on the screen. On the screen with UV ink, the ink dissolved quickly, wiped off easily, rinsed clean of residue, but left a moderate ink stain. When used on the screen with water-based ink, more time and effort were needed to remove the ink which seemed to dry in the screen. With the extra effort, the ink was removed except for a light ink stain. For each of the three screens, one rag was used to remove the ink. The technician noted that the ink remover had an unpleasant odor, but that it was not very strong.

On all three screens, the emulsion remover dissolved the stencil with some scrubbing. The remainder of the stencil came off easily with the pressure wash. There was no emulsion stain or residue on any of the screens. On the screen with the solvent-based ink, a moderate ink stain remained after using the emulsion remover. The UV ink screen and the water-based ink screen had light stains. On all the screens, the haze remover lightened the ink stain, but did not remove it completely; a light ink stain was still visible.

Summary of Performance at the Volunteer Facilities

This section summarizes the product system performance as recorded by the printers using the products at both of the demonstration facilities. The table at the end of the section summarizes both the field demonstration performance data and the results of the product tests performed at SPTF.

Ink Remover: There were some differences between the two facilities in their evaluations of the performance of Product System Epsilon. Facility 20 found the ink remover was effective, but it took longer to breakdown the ink than their standard product. Facility 24 had very good results with the ink remover. They felt it worked as well as the products they had used previously and they were using less product per screen. The ink remover worked well on both UV and solvent-based inks, but the UV ink was easier to clean than the solvent-based ink.

Emulsion Remover: The alternative emulsion remover performance was very good at both facilities. The two facilities reported that the performance was even better than their standard products; it dissolved the stencil quickly and easily.

Haze Remover: Both facilities thought that the haze remover performance was acceptable, and in most cases, it worked as well as their other products.

TABLE 6.11: PRODUCT SYSTEM EPSILON PERFORMANCE

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
In-field Demonstrations at Volunteer Printing Facilities							
Facility 20 *Solvent-based vinyl, enamels* *Average screen size = 2538 in²*	*Ink remover*	no data	3.0 oz. (n=1)	no data	Moderate	Removed ink well, but took some extra time.	• Data forms were not received from this facility. • All information is based on weekly phone calls.
	Emulsion Remover	no data	3.3 ± 0.6 oz. (n=3)	no data	Moderate	Easily removed stencil.	
	Haze Remover	no data	4.0 ± 1.7 oz. (n=3)	no data	Moderate	Lightened ink stain.	
Facility 24 *Solvent-based and UV-curable* *Average screen size = 1296 in²*	*Ink remover*	10.3 ± 26.1 hrs (n=14)	4.2 ± 1.7 oz. (n=14)	3.7 ± 1.5 mins (n=13)	Moderate	Removed ink well, especially UV ink.	• All screens could be reused after reclamation. • Some screens could <u>not</u> be used for reverse printing. • Light ink stain remained.
	Emulsion Remover	13.8 ± 12.2 hrs (n=14)	4.2 ± 1.9 oz. (n=13)	3.7 ± 1.1 mins (n=14)	Low	Easily removed stencil.	
	Haze Remover	2.9 ± 2.1 mins (n=14)	1.5 ± 0.5 oz. (n=14)	10.9 ± 4.7 mins (n=14)	Low	Usually removed haze.	
Laboratory Testing at SPTF							
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.5 oz	3.9 mins	Low	Dissolved ink well; gray haze left on screen.	
	Emulsion Remover	24 hours	1.0 oz	3.4 mins	Moderate	Dissolved stencil; medium ink stain remaining.	
	Haze Remover	0 mins	1.0 oz	31.8 mins	Low	Lightened ink stain.	
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.5 oz	3.3 mins	Low	Dissolved ink well; has unpleasant odor.	
	Emulsion Remover	24 hours	1.5 oz	3.8 mins	Moderate	Dissolved stencil; light ink stain remaining.	
	Haze Remover	0 mins	1.0 oz	2.2 mins	Low	Lightened ink stain.	
SPTF Water-based Ink	*Ink Remover*	15 mins	1.5 oz	5.6 mins	Moderate	Dissolved ink with scrubbing.	
	Emulsion Remover	24 hours	1.0 oz	3.2 mins	Moderate	Dissolved stencil; light ink stain remaining.	
	Haze Remover	0 mins	1.0 oz	32.8 mins	Low	Lightened ink stain.	

TABLE 6.12

COST ANALYSIS FOR ALTERNATIVE EPSILON

Description		Baseline	Alternative System Epsilon	
			Facility 20	Facility 24
Facility Characteristics				
Average screen size (in^2)		2,127	2,538	1,296
Average # screens/day		6	8	1
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	9.7	18.3
	Cost ($)	$5.33	$2.12	$4.00
Materials and Equipment	# of rags used	3	7.0	3.8
	Cost ($)	$0.45	1.05	0.57
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	3.0	4.2
	Cost ($)	$0.22	0.18	0.26
	Emulsion Remover Average Volume (oz.)	3.5	3.3	4.2
	Cost ($)	$0.13	0.09	0.11
	Haze Remover Average Volume (oz.)	3.0	4.0	1.5
	Cost ($)	$0.12	0.27	0.10
Hazardous Waste Disposal	Amount (g)	34	112	57
	Cost ($)	$0.02	0.08	0.04
Totals				
Total Cost/Screen		$6.27	3.79	5.08
Normalized*		$6.27	3.08	5.29
Total Cost/year		$9,399	7,097	1,269
Normalized*		$9,399	4,624	7,930

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

PRODUCT SYSTEM GAMMA

For Product System Gamma, this section describes the performance results from the laboratory performance tests and from the volunteer facility demonstrations, and also presents two tables: one summarizes the performance results and the other presents costing data. For information on the operating conditions of the two volunteer printing facilities where Product System Gamma was demonstrated, or on the specific details of the product system performance at each of the facilities, see Appendix I.

Product System Gamma, demonstrated at Facilities 16 and 25, consisted of an ink remover, an emulsion remover, and a haze remover. Facility 16 prints vehicle markings; Facility 25 prints appliance panel overlays, back-lit automotive panels, and store displays. During the four week demonstration period, Facility 16 reclaimed 55 screens although ink remover was only used on seven screens and haze remover was only used on three screens; Facility 25 reclaimed 54 screens but the ink remover and haze remover were only used on about half of these. During the demonstrations, both Facility 16 and 25 used solvent-based inks; Facility 16 used a capillary film emulsion and Facility 25 used a direct photo stencil.

Performance in the Laboratory

Product System Gamma was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-cured ink, and one with a water-based ink). The ink remover performance varied depending on the type of ink used. The emulsion remover and haze remover performance was consistent for all three screens. All products were applied according to the manufacturer's instructions.

On the screen with the solvent-based ink and the screen with UV ink, the ink remover dissolved the ink well with no effect on the stencil. On the water-based ink screen, however, heavy scrubbing and more product were needed to remove the ink. While scrubbing, the stencil started to break down in the half-tone area. For all the screens, only one rag was used for ink removal.

The emulsion remover easily dissolved the stencil with only light scrubbing on all three screens, leaving no ink or emulsion residue behind. The technician noted that most of the stencil dissolved while she was brushing, and the pressure wash took off the remainder. The screens did have a moderate ink stain remaining. Subsequent application of the haze remover lightened the ink stains so that a light to very light ink stain remained.

Summary of Performance at the Volunteer Facilities

The operating conditions for each facility that volunteered to reclaim their screens using Product System Gamma for one month are described below. This information is provided as a basis of comparison to review the performance results of alternative product system at each of these two facilities.

Ink Remover: Facility 16 reported that the ink remover left an unacceptable amount of ink on the screen and required a lot of physical effort. Facility 25 also reported that the ink remover was not acceptable, leaving ink residue on the screen, especially in the open areas of the screen mesh. The ink remover required much more time to apply (up to more than twice as long in some cases) with much greater physical effort than the products normally used at these facilities. Leaving the ink remover to sit for 3 - 5 minutes on the screen helped improve performance on the screen areas covered with emulsion, but did not help to remove the ink on the open screen areas.

Emulsion Remover: Both facilities reported that the emulsion remover worked very well. Facility 16 was able to shorten the time between application and rinse from the recommended one or two minutes to less than one minute without compromising the product performance. Facility 25 improved the emulsion remover performance by wetting the screen before applying the emulsion remover.

Haze Remover: Neither facility found the performance of the haze remover to be acceptable. They found the haze remover did not remove the ink haze left in the screen, which resulted in ghost images in future print jobs. Both facilities had to use their standard haze remover on their screens before they could be reused.

TABLE 6.13: PRODUCT SYSTEM GAMMA PERFORMANCE

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
In-field Demonstrations at Volunteer Printing Facilities							
Facility 16	*Ink remover*	3.0 ± 2.4 mins (n=7)	5.0 ± 2.0 oz. (n=7)	11.1 ± 6.6 mins (n=7)	Moderate	Ink and oily residue left in mesh.	• Did not use the ink remover or haze remover due to poor performance.
Solvent-based ink	*Emulsion Remover*	52.4 ± 272.0 mins (n=55)	2.3 ± 1.3 oz. (n=51)	1.8 ± 1.8 mins (n=50)	Low	Easily removed stencil on all screens.	
Average screen size = 2294 in²	*Haze Remover*	0.0 ± 0.0 mins (n=55)	3.3 ± 1.5 oz. (n=3)	3.0 ± 0.0 mins (n=1)	Moderate	Did not remove ghost images.	
Facility 25	*Ink remover*	19.2 ± 15.0 mins (n=23)	10.8 ± 4.6 oz. (n=22)	11.7 ± 5.2 mins (n=22)	High	Excessive ink residue left in screen.	• Stopped using ink remover and haze remover after 2 weeks due to poor results.
Solvent-based ink	*Emulsion Remover*	13.2 ± 31.1 hrs (n=54)	1.2 ± 0.4 oz. (n=50)	3.0 ± 0.3 mins (n=50)	Low	Quickly, easily removed stencil.	
Average screen size = 1848 in²	*Haze Remover*	4.6 ± 11.8 hrs (n=54)	5.3 ± 7.2 oz. (n=23)	2.2 ± 0.4 mins (n=12)	Low	Ink haze remained in screen.	
Laboratory Testing at SPTF							
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.5 oz.	3.8 mins	Low	Ink dissolved well. No effect on stencil.	
	Emulsion Remover	24 hrs	1.0 oz.	3.9 mins	Low	Removed stencil easily. Moderate ink stain remaining.	
	Haze Remover	0 mins	1.0 oz.	1.8 mins	Low	Lightened stain.	
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.5 oz.	3.5 mins	Low	Ink dissolved well. No effect on stencil.	
	Emulsion Remover	24 hrs	1.5 oz.	4.8 mins	Low	Removed stencil easily. Moderate ink stain remaining.	
	Haze Remover	0 mins	0.5 oz.	1.8 mins	Low	Lightened stain.	
SPTF Water-based Ink	*Ink Remover*	15 mins	2.0 oz.	5.8 mins	Moderate	Heavy scrubbing required to dissolve ink. Parts of stencil deteriorated.	
	Emulsion Remover	24 hrs	1.0 oz.	4.8 mins	Low	Removed stencil easily. Moderate ink stain remaining.	
	Haze Remover	0 mins	1.0 oz.	2.0 mins	Low	Lightened stain.	

TABLE 6.14

COST ANALYSIS FOR ALTERNATIVE GAMMA

Description		Baseline	Alternative System Gamma Facility 16	Alternative System Gamma Facility 25
Facility Characteristics				
Average screen size (in^2)		2,127	2,294	1,848
Average # screens/day		6	20	25
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	15.9	16.9
	Cost ($)	$5.33	$3.48	$3.70
Materials and Equipment	# of rags used	3	5.0	7.0
	Cost ($)	$0.45	0.75	1.04
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	5.0	10.8
	Cost ($)	$0.22	0.43	0.92
	Emulsion Remover Average Volume (oz.)	3.5	2.3	1.2
	Cost ($)	$0.13	0.24	0.12
	Haze Remover Average Volume (oz.)	3.0	3.3	5.3
	Cost ($)	$0.12	0.24	0.39
Hazardous Waste Disposal	Amount (g)	34	0	0.0
	Cost ($)	$0.02	0	0.0
Totals				
Total Cost/Screen		$6.27	5.14	6.17
Normalized*		$6.27	5.06	5.61
Total Cost/year		$9,399	25,708	38,547
Normalized*		$9,399	7,590	8,417

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

PRODUCT SYSTEM MU

For Product System Mu, this section describes the performance results from the laboratory performance tests and from the volunteer facility demonstrations, and also presents two tables: one summarizes the performance results and the other presents costing data. For information on the operating conditions of the two volunteer printing facilities where Product System Mu was demonstrated, or on the specific details of the product system performance at each of the facilities, see Appendix I.

Product System Mu consisted of an ink remover, an emulsion remover, and a haze remover. The performance of the product system was demonstrated at Facilities 17 and 22. Facility 17 prints decals; Facility 22 prints back-lit automotive overlays. During the four week demonstration period, Facility 17 reclaimed 18 screens and Facility 22 reclaimed 44 screens. For the performance demonstrations, Facility 17 used primarily UV-cured inks, and Facility 22 used solvent-based inks; both facilities used a direct photo stencil.

Performance in the Laboratory

Product System Mu was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-cured ink, and one with a water-based ink). The ink remover and the haze remover performance varied depending on the type of ink used. The emulsion remover and the haze remover performance was consistent on all three screens.

On the screen with the solvent-based ink and the screen with UV ink, the ink remover dissolved the ink easily with little scrubbing and no effect on the emulsion. On the water-based ink screen, however, the ink dried in the screen and heavy scrubbing and more product were needed to remove the ink. While scrubbing, the stencil started to break down in the half tone area. For all three screens, one wipe was used to remove the ink.

The emulsion remover easily dissolved the stencil with only light scrubbing on all three screens, leaving no ink or emulsion residue behind. The screens did have a light-to-moderate ink stain was remaining. Subsequent application of the haze remover lightened the ink stains of the UV ink and the water-based ink screen, so that a very light ink stain remained. The haze remover did not lighten the moderate ink stain on the screen with the solvent-based ink.

Summary of Performance at the Volunteer Facilities

This section summarizes the product system performance as recorded by the printers using the products at both of the demonstration facilities. The table at the end of the section summarizes both the field demonstration performance data and the results of the product tests performed at SPTF.

Ink Remover: Facility 17 reported that the ink remover worked well, although black (UV-cured) inks were more difficult to remove than the other UV-cured inks. Facility 22 reported that the ink remover performance was unacceptable for their solvent-based ink system. Extra physical effort and time were needed, and a lot of product was applied, but an ink residue still remained on the screen. The standard ink remover used at Facility 22 is chemically very different from the alternative ink remover supplied as part of Product System Mu. These differences may have caused adverse chemicals interactions on older screens.

Emulsion Remover: The emulsion remover performance was very good at both facilities. It removed the emulsion quickly, easily, and completely. Facility 22 commented that the emulsion remover performance was "excellent."

Haze Remover: Facility 17 reported that the haze remover worked better and faster than one of their usual products, but not as well as the haze remover that they use for difficult stains. The haze remover's performance was also affected by the number of impressions in the previous test run: it did not work as well after runs with many impressions. Facility 22 reported that the haze remover did not work at all and they had to use their standard product before they could reuse the screen. There was no visible change in the haze when the haze remover was applied.

TABLE 6.15: PRODUCT SYSTEM MU PERFORMANCE

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
In-field Demonstrations at Volunteer Printing Facilities							
Facility 17 UV ink (one screen with solvent-based ink) Average screen size = 2270 in^2	*Ink remover*	13.9 ± 16.9 hrs (n=19)	2.7 ± 0.7 oz. (n=18)	7.0 ± 3.9 mins (n=19)	Moderate	Removed ink well.	• Haze remover required at least one hour of wait time. • All screens with UV ink were reusable.
	Emulsion Remover	4.9 ± 1.7 hrs (n=19)	2.6 ± 0.6 oz. (n=18)	5.7 ± 2.0 mins (n=19)	Low	Removed stencil easily.	
	Haze Remover	21.3 ± 10.5 mins (n=19)	2.9 ± 0.7 oz. (n=18)	data not recorded	Moderate	Worked well on moderate haze.	
Facility 22 Solvent-based ink Average screen size = 1520 in^2	*Ink remover*	15.6 ± 12.6 mins (n=20)	11.6 ± 1.4 oz. (n=20)	30.5 ± 12.0 mins (n=20)	High	Left ink residue in the screen.	• Used their standard haze remover before reusing screens. • Emulsion remover worked better than any other they tried.
	Emulsion Remover	22.5 ± 72.5 hrs (n=47)	1.1 ± 0.3 oz. (n=47)	2.8 ± 0.5 mins (n=47)	Low	Removed stencil easily.	
	Haze Remover	2.2 ± 1.2 mins (n=47)	1.3 ± 0.5 oz. (n=6)	1.3 ± 0.6 mins (n=3)	Moderate	Left ghost image in screens.	
Laboratory Testing at SPTF							
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.0 oz.	3.5 mins	Low	Dissolved ink easily.	
	Emulsion Remover	24 hrs	0.5 oz.	3.6 mins	Moderate	Dissolved stencil well. Moderate ink stain remaining.	
	Haze Remover	0 mins	1.0 oz.	2.0 mins	Low	Haze remover did not lighten ink stain.	
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.5 oz.	2.9 mins	Low	Dissolved ink very easily.	
	Emulsion Remover	24 hrs	1.0 oz.	3.3 mins	Moderate	Dissolved stencil well. Light ink stain remaining.	
	Haze Remover	0 mins	0.5 oz.	2.0 mins	Low	Lightened ink stain.	
SPTF Water-based Ink	*Ink Remover*	15 mins	2.0 oz.	6.1 mins	High	Excessive scrubbing and product required to remove dried ink.	
	Emulsion Remover	24 hrs	1.5 oz.	3.1 mins	Moderate	Dissolved stencil well. Light ink stain remaining.	
	Haze Remover	0 mins	0.5 oz.	2.0 mins	Low	Lightened ink stain.	

TABLE 6.16

COST ANALYSIS FOR ALTERNATIVE MU

Description		Baseline	Alternative System Mu: Facility 17	Alternative System Mu: Facility 22
Facility Characteristics				
Average screen size (in^2)		2,127	2,270	1,520
Average # screens/day		6	25	12
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	17.2	34.6
	Cost ($)	$5.33	$3.75	$7.58
Materials and Equipment	# of rags used	3	1.0	10.8
	Cost ($)	$0.45	0.15	1.61
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	2.7	11.6
	Cost ($)	$0.22	0.16	0.70
	Emulsion Remover Average Volume (oz.)	3.5	2.6	1.1
	Cost ($)	$0.13	0.21	0.09
	Haze Remover Average Volume (oz.)	3.0	2.9	1.3
	Cost ($)	$0.12	0.17	0.08
Hazardous Waste Disposal	Amount (g)	34	110	73
	Cost ($)	$0.02	0.08	0.05
Totals				
Total Cost/Screen		$6.27	4.53	10.11
Normalized*		$6.27	4.79	9.33
Total Cost/year		$9,399	28,295	30,338
Normalized*		$9,399	7,185	13,997

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

PRODUCT SYSTEM OMICRON-AE

Product System Omicron-AE and Product System Omicron-AF were submitted for demonstration by the same manufacturer. They have the same ink remover and the same emulsion remover, but each one has a different haze remover to complete the system. Although these systems do share a common ink remover and emulsion remover, Omicron-AE and Omicron-AF are each evaluated as a separate product system in this documentation. It was the intention of the Performance Demonstrations to evaluate reclamation systems as a whole, not individual products, whenever possible.

For Product System Omicron-AE, this section describes the performance results from the laboratory performance tests and from the volunteer facility demonstrations, and also presents two tables: one summarizes the performance results and the other presents costing data. For information on the operating conditions of the two volunteer printing facilities where Product System Omicron-AE, was demonstrated, or on the specific details of the product system performance at each of the facilities, see Appendix I.

The performance of Omicron-AE was demonstrated at Facilities 2 and 19. This product system consisted of an ink remover, an emulsion remover, and a haze remover. A degreaser also accompanied this product system and was used by one of the facilities, however, detailed information on the performance of the degreaser is not included in the scope of this project. Facility 2 prints signs, and displays; Facility 19 prints overlays, and membrane switches. During the demonstration, Facility 2 reclaimed 30 screens using solvent-based inks and a direct photo stencil over a 4 week period. Facility 19 did not participate in the demonstrations after the observer's one day visit. During the visit, they reclaimed four screens, but based on the poor results of those first reclamations, they decided not to participate in the project. Neither facility tried alternative application techniques to improve product performance.

Performance in the Laboratory

Product System Omicron-AE was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-cured ink, and one with a water-based ink). Products were applied according to the manufacturer's recommended application procedure. On the screens with the solvent-based ink and with UV ink, the ink dissolved well with little effort. On the solvent-based ink screen, the stencil was affected in the half-tone area, but there was no effect on the stencil on the UV ink screen. Six wipes were used to remove the ink from each screen. On the screen with water-based ink, the ink dissolved well, however, extra scrubbing was needed. The stencil was affected in the half-tone area. Again, six wipes were used.

On all three screens, the emulsion remover dissolved the stencil effectively. On the screen with solvent-based ink and the UV ink screen, moderate scrubbing was required to break up the stencil and the pressure wash remove the stencil completely. A light to moderate ink stain remained on each screen. On the screen with water-based ink, the stencil dissolved easily with only light scrubbing, but there was a small amount of ink residue remaining in the half-tone areas, in addition to a moderate ink stain.

The haze remover lightened the stains on all three screens and removed the ink residue on the water-based ink screen. However, all screens did have some ink stain remaining after the application of the haze remover.

Summary of Performance at the Volunteer Facilities

This section summarizes the product system performance as recorded by the printers using the products at both of the demonstration facilities. The table at the end of the section summarizes both the field demonstration performance data and the results of the product tests performed at SPTF.

Ink Remover: Facility 2 reported that the ink remover performed poorly and required a lot more scrubbing than their usual product. The chemical composition of the alternative ink remover was extremely different than the constituents of the facility's standard product. Adverse interactions may have occurred because of these chemical differences. The ink remover seemed to work better when used immediately after printing, but the performance was still not acceptable. At Facility 19, the ink remover had to be re-applied and scrubbed into the screen repeatedly, and all residual ink was still not removed.

Emulsion Remover: In general, Facility 2 liked the emulsion remover better than their usual product, although it took extra time to use the hand sprayer and the emulsion remover was not as effective when thick ink residue was present. Facility 19 was not satisfied with the emulsion remover performance. They reported that the emulsion remover had to be re-applied and scrubbed into the screen repeatedly; even then residual emulsion was left on the screen.

Haze Remover: Both facilities found the haze remover performance to be unacceptable. Facility 2 saw no reduction in haze after applying the product. At Facility 19, the haze remover did not completely remove the haze. This facility, however, had very high standards in terms of haze removal; other facilities would have been satisfied with this level of haze removal. It should be noted that both facilities used standard haze removers that were very different chemically than the alternative haze remover. On screens that were reclaimed many times, there is potential for adverse effects due to interaction of the standard and alternative products.

TABLE 6.17: PRODUCT SYSTEM OMICRON-AE PERFORMANCE

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
In-field Demonstrations at Volunteer Printing Facilities							
Facility 2	*Ink remover*	7.1 ± 9.3 hrs (n=14)	12.6 ± 13.1 oz. (n=7)	18.6 ± 15.5 mins (n=7)	Moderate	Ink residue not removed from mesh.	• Only 7 screens reclaimed w/system, due to poor performance.
Solvent-based ink	*Emulsion Remover*	1.3 ± 3.7 hrs (n=30)	7.5 ± 3.7 oz. (n=26)	6.6 ± 3.4 mins (n=26)	Low	Easily, completely removed stencil.	
Average screen size = 5663 in²	*Haze Remover*	2.2 ± 6.7 hrs (n=30)	14.6 ± 5.1 oz. (n=7)	15.0 ± 4.1 mins (n=7)	Low	Seemed to have no effect on the haze.	
Facility 19	*Ink remover*	3.7 ± 1.5 hrs (n=3)	2.3 ± 1.2 oz. (n=3)	7.3 ± 4.5 mins (n=3)	High	Ink remained in screen after several applications.	• Did not participate after observer's visit, due to poor product performance.
Solvent-based ink	*Emulsion Remover*	not recorded (n=0)	1.3 ± 0.6 oz. (n=3)	3.3 ± 0.6 mins (n=3)	Moderate	Reapplication needed to remove emulsion.	
Average screen size = 957 in²	*Haze Remover*	3.0 mins (n=1)	2.3 ± 2.5 oz. (n=4)	10.0 ± 9.3 mins (n=4)	High/ Moderate	Lightened the ink stain.	
Laboratory Testing at SPTF							
SPTF Solvent-based Ink	*Ink Remover*	15 mins	3.0 oz.	8.3 mins	Low	Dissolved ink well. Stencil affected in areas.	
	Emulsion Remover	24 hrs	0.5 oz.	3.8 mins	Moderate	Dissolved stencil. Light ink stain remaining.	
	Haze Remover	0 mins	0.5 oz.	5.0 mins	Low	Lightened, but did not remove, ink stain.	
SPTF UV-curable Ink	*Ink Remover*	15 mins	2.0 oz.	7.3 mins	Low	Dissolved ink well.	
	Emulsion Remover	24 hrs	0.5 oz.	4.2 mins	Moderate	Dissolved stencil. Medium ink stain remaining.	
	Haze Remover	0 mins	0.5 oz.	5.1 mins	Low	Lightened, but did not remove, ink stain.	
SPTF Water-based Ink	*Ink Remover*	15 mins	3.0 oz.	7.2 mins	Moderate	Dissolved ink with wiping. Stencil affected in areas.	
	Emulsion Remover	24 hrs	1.0 oz.	3.5 mins	Low	Dissolved stencil. Medium ink stain and residue.	
	Haze Remover	0 mins	1.0 oz.	5.5 mins	Low	Lightened, but did not remove, ink stain.	

TABLE 6.18

COST ANALYSIS FOR ALTERNATIVE OMICRON AE

Description		Baseline	Alternative System Omicron AE	
			Facility 2	Facility 19
Facility Characteristics				
Average screen size (in^2)		2,127	5,663	957
Average # screens/day		6	6	70
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	40.2	20.7
	Cost ($)	$5.33	$8.80	$4.52
Materials and Equipment	# of rags used	3	16	0
	Cost ($)	$0.45	2.43	0
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	12.6	2.3
	Cost ($)	$0.22	0.96	0.18
	Emulsion Remover Average Volume (oz.)	3.5	7.5	1.3
	Cost ($)	$0.13	0.56	0.10
	Haze Remover Average Volume (oz.)	3.0	12.6	2.3
	Cost ($)	$0.12	0.89	0.16
Hazardous Waste Disposal	Amount (g)	34	0	0
	Cost ($)	$0.02	0	0
Totals				
Total Cost/Screen		$6.27	13.65	4.96
Normalized*		$6.27	10.85	5.49
Total Cost/year		$9,399	20,470	86,787
Normalized*		$9,399	16,278	8,240

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

PRODUCT SYSTEM OMICRON-AF

Product System Omicron-AE and Product System Omicron-AF were submitted for demonstration by the same manufacturer. They have the same ink remover and the same emulsion remover, but each one has a different haze remover to complete the system. Although these systems do share a common ink remover and emulsion remover, Omicron-AE and Omicron-AF are each evaluated as a separate product system in this documentation. It was the intention of the Performance Demonstrations to evaluate reclamation systems as a whole, not individual products, whenever possible.

For Product System Omicron-AF, this section describes the performance results from the laboratory performance tests and from the volunteer facility demonstrations, and also presents two tables: one summarizes the performance results and the other presents costing data. For information on the operating conditions of the two volunteer printing facilities where Product System Omicron-AF, was demonstrated, or on the specific details of the product system performance at each of the facilities, see Appendix I.

Product System Omicron-AF is a water-based system and it consisted of an ink remover, an emulsion remover, and a haze remover. A degreaser accompanied this product system, however, detailed information on the performance of the degreaser is not included in the scope of this project. The performance of the product was demonstrated at Facilities 4 and 18. Facility 4 prints decals using UV-cured inks and direct photo stencils; Facility 18 prints nameplates, panels, and graphic overlays using solvent-based inks and either direct photo stencils or capillary film emulsions. During the demonstration periods, Facility 4 used the alternative products to reclaim 19 screens over a 2 week period and Facility 18 reclaimed 32 screens over 4 weeks. Facility 4 discontinued use of the alternative product system after two weeks, due to the poor performance of the ink remover and the haze remover.

Performance in the Laboratory

Product System Omicron-AF was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-cured ink, and one with a water-based ink). On the screen with the solvent-based ink, the ink dissolved well with moderate effort (5 wipes were used). On the last rag there was a slight blue color (the color of the stencil) which may indicate that the ink remover could deteriorate the stencil. Ink remover performance on the screen with UV-cured ink was similar expect there was some red coloring on the rag as well as blue. The red tint could indicate an effect on the adhesive (which is red) that holds the screen to the frame. The UV-cured ink screen also required moderate effort to remove the ink and 6 rags were used. Compared to the other two screens, the screen with water-based ink required additional time, effort (7 rags), and product to loosen the ink. Also on the water-based ink screen, the technician noted that the ink remover started to deteriorate the stencil.

On all three screens, the emulsion remover dissolved the stencil quickly and with moderate scrubbing effort and the pressure rinse removed it completely. On the screen with solvent-based ink, a moderate ink stain remained on the screen after using the emulsion remover. The UV screen had a lighter stain. The water-based ink screen had a moderate stain with some ink residue remaining in the half-tone area. The haze remover lightened the stains on all three screens and removed the ink residue on the water-based ink screen.

Products were applied according to the manufacturer's recommended application procedure. After using the haze remover, the technician noted that there was a small hole in the screen with solvent-based ink that was not there before using the haze remover.

<u>Summary of Performance at the Volunteer Facilities</u>

This section summarizes the product system performance as recorded by the printers using the products at both of the demonstration facilities. The table at the end of the section summarizes both the field demonstration performance data and the results of the product tests performed at SPTF.

Ink Remover: At Facility 4, the ink remover removed the ink from the mesh satisfactorily, however, residue remained in the stencil area on most of the screens. The printer felt the ink residue was minimal, and if he were using his standard haze remover, this residue would not have been a problem. Facility 18 reported that the ink remover worked as well as their standard products.

Emulsion and Haze Remover: The emulsion remover worked very well at both facilities. It removed the stencil completely and easily. The haze remover performance was not acceptable at either facility. Facility 4 reported that the haze remover was not effective in removing any of the ink haze, even with vigorous scrubbing and procedural modifications. A ghost image appeared on subsequent print jobs, which required that the printer clean the screens again with his standard product. At Facility 18, the haze remover left too much haze under all conditions and their standard haze remover had to be used after the alternative products before the screen could be reused. Because of this poor performance, the facility stopped using the haze remover during the first week of demonstrations.

TABLE 6.19: PRODUCT SYSTEM OMICRON-AF PERFORMANCE

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
In-field Demonstrations at Volunteer Printing Facilities							
Facility 4 *UV-curable* *Average screen size = 1577 in^2*	*Ink remover*	46.1 ± 49.3 hrs (n=22)	1.6 ± 0.7 oz. (n=22)	5.1 ± 0.6 mins (n=12)	Moderate	Ink residue in stencil area.	• Most screens could not be reused due to a haze. • A ghost image appeared when the screens were reused. • The facility discontinued use after 2 weeks.
	Emulsion Remover	5.5 ± 10.2 hrs (n=22)	1.4 ± 0.5 oz. (n=22)	4.9 ± 0.3 mins (n=12)	Low	Easily removed stencil.	
	Haze Remover	4.1 ± 2.0 mins (n=22)	2.1 ± 0.7 oz. (n=12)	5.0 ± 0.2 mins (n=12)	High	Did not remove ghost image from most screens.	
Facility 18 *Solvent-based ink* *Average screen size = 1150 in^2*	*Ink remover*	28.5 ± 28.0 hrs (n=47)	2.2 ± 0.5 oz. (n=46)	2.7 ± 0.9 mins (n=46)	Low	Removed ink well.	• Facility was pleased with the ink and emulsion removers. • They switched back to their own haze remover after one week.
	Emulsion Remover	1.2 ± 1.1 mins (n=47)	3.6 ± 1.2 oz. (n=47)	4.0 ± 1.1 mins (n=47)	Low	Easily removed stencil.	
	Haze Remover	0.8 ± 2.7 mins (n=47)	1.9 ± 0.7 oz. (n=11)	4.1 ± 1.4 mins (n=11)	Low	Did not reduce haze.	
Laboratory Testing at SPTF							
SPTF Solvent-based Ink	*Ink Remover*	15 mins	1.5 oz.	5.7 mins	Moderate	Ink dissolved well.	
	Emulsion Remover	24 hrs	1.0 oz.	4.1 mins	Moderate	Stencil dissolved easily. Moderate ink stain remaining.	
	Haze Remover	0 mins	1.0 oz.	4.0 mins	Low	Lightened the ink stain.	
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.5 oz.	6.5 mins	Low	Ink dissolved well.	
	Emulsion Remover	24 hrs	1.0 oz.	4.1 mins	Low	Stencil dissolved easily. Light ink stain remaining.	
	Haze Remover	0 mins	0.5 oz.	4.5 mins	Low	Lightened the ink stain.	
SPTF Water-based Ink	*Ink Remover*	15 mins	2.5 oz.	7.8 mins	Moderate	Ink dissolved with extra effort and product.	
	Emulsion Remover	24 hrs	1.0 oz.	4.4 mins	Moderate	Stencil dissolved easily. Some ink residue remaining.	
	Haze Remover	0 mins	1.0 oz.	4.2 mins	Low	Removed residue; lightened stain.	

TABLE 6.20

COST ANALYSIS FOR ALTERNATIVE OMICRON - AF

Description		Baseline	Alternative System Omicron - AF: Facility 4	Alternative System Omicron - AF: Facility 18
Facility Characteristics				
Average screen size (in^2)		2,127	1,210	1,150
Average # screens/day		6	6	13
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	15.0	10.8
	Cost ($)	$5.33	$3.28	$2.37
Materials and Equipment	# of rags used	3	1.3	1.3
	Cost ($)	$0.45	0.20	0.20
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	1.6	2.2
	Cost ($)	$0.22	0.12	0.17
	Emulsion Remover Average Volume (oz.)	3.5	1.4	3.6
	Cost ($)	$0.13	0.10	0.27
	Haze Remover Average Volume (oz.)	3.0	2.1	1.9
	Cost ($)	$0.12	0.15	0.14
Hazardous Waste Disposal	Amount (g)	34	0	0
	Cost ($)	$0.02	0	0
Totals				
Total Cost/Screen		$6.27	3.86	3.14
Normalized*		$6.27	4.45	3.89
Total Cost/year		$9,399	5,784	9,823
Normalized*		$9,399	6,675	5,836

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

PRODUCT SYSTEM PHI

For Product System Phi, this section describes the performance results from the laboratory performance tests and from the volunteer facility demonstrations, and also presents two tables: one summarizes the performance results and the other presents costing data. For information on the operating conditions of the two volunteer printing facilities where Product System Phi, was demonstrated, or on the specific details of the product system performance at each of the facilities, see Appendix I.

Product System Phi consisted of an ink remover, an emulsion remover, and a haze remover. It's performance was demonstrated at Facility 5 and Facility 23. Facility 5 employs approximately 15 people with 3 employees involved in the screen printing area. They print interior signs, markings on parts, and identification badges. Facility 23 employs five people and prints mainly on plastics. Their products include front panels, overlays, and labels. Over a four week period, Facility 5 reclaimed 40 screens. Facility 23 used Product System Phi for two weeks and reclaimed 8 screens. During the demonstrations, both facilities primarily used solvent-based vinyl inks, but they also tried System Phi on acrylic vinyl, epoxy, and metallic inks. Facility 5 used a capillary film emulsion on a polyester screen and Facility 23 used a dual-cure emulsion on a multifilament polyester screen.

Performance in the Laboratory

Product System Phi was tested at SPTF on two screens (one with a solvent-based ink, and one with a UV-cured ink). This product is not recommended for use on water-based inks. On both screens, the ink dissolved quickly with minimal effort. There was a slight blue color on the wipe (the color of the stencil), but the stencil did not appear to be damaged or deteriorated. On the screen with solvent-based ink, six rags were needed to remove the ink, and on the UV ink screen, five rags were used. The technician noticed a slight odor.

The emulsion remover also worked well; it completely dissolved the stencil with only light scrubbing on both screens. After using the emulsion remover, the screen with solvent-based ink had a very light stain and slight ink residue in small areas. The haze remover lightened the stain only slightly, but it removed the ink residue. The screen with UV-cured ink had a dark ink stain and the haze remover lightened it somewhat, but did not remove it completely. The technician noted that the haze remover was very easy to use and required minimal effort. There was a slight odor to the product, but it was not unpleasant.

The recommended application procedure was followed with a few slight variations. The ink remover was allowed to sit on the screen for 30 seconds before it was rubbed in with a sponge. The haze remover was removed with a pressure wash.

Summary of Performance at the Volunteer Facilities

This section summarizes the product system performance as recorded by the printers using the products at both of the demonstration facilities. The table at the end of the section summarizes both the field demonstration performance data and the results of the product tests performed at SPTF.

Ink Remover: Both facilities reported similar results with Product System Phi. At Facility 5, the ink remover broke down the ink effectively but required more effort than their own ink remover. Facility 23 found that the ink remover performance was inconsistent; it worked well on metallic inks, but did not remove ink from around the edges of the stencil when using vinyl ink. Both facilities noticed that the ink remover tended to deteriorate the stencil if it was not wiped off immediately after application. For this reason, the facilities felt that this product should not be used for in-process ink removal.

Emulsion Remover: The emulsion remover was very effective and it easily removed the stencil with very little scrubbing. Both facilities reported the System Phi emulsion remover performed better than the product they were using before the demonstrations.

Haze Remover: Facility 5 reported that a haze remained on the screen after using the haze remover, but it did not affect future print image quality. Over time, the printer felt this haze could potentially deteriorate the screen mesh. Facility 23 reported that the haze remover left a ghost image and some screens could not be reused for reverse printing or for printing with transparent inks.

TABLE 6.21: PRODUCT SYSTEM PHI PERFORMANCE

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
In-field Demonstrations at Volunteer Printing Facilities							
Facility 5 *Solvent-based ink* *Average screen size = 2815 in^2*	*Ink remover*	2.5 ± 9.6 mins (n=40)	1.3 ± 0.5 oz. (n=40)	3.7 ± 4.2 mins (n=40)	Moderate	Light/Moderate ink haze on 35% of screens.	• Ink remover deteriorated the stencil. • Light ink stain remained after reclamation.
	Emulsion Remover	1.3 ± 0.6 mins (n=40)	1.7 ± 0.5 oz. (n=40)	2.6 ± 0.5 mins (n=40)	Moderate	Quickly, easily removed stencil.	
	Haze Remover	8.2 ± 37.6 mins (n=40)	1.1 ± 0.5 oz. (n=40)	1.6 ± 0.5 mins (n=40)	Moderate	Did not consistently remove haze.	
Facility 23 *Solvent-based vinyl ink* *Average screen size = 883 in^2*	*Ink remover*	50.6 ± 40.6 hrs (n=9)	2.0 ± 1.9 oz. (n=9)	6.9 ± 10.6 mins (n=9)	Low	Inconsistent performance. Worked well on metallic inks; did not work well on other inks used.	• Facility stopped using the product after 2 weeks because of the additional time required for the haze remover and personnel problems. • Ink remover deteriorated the stencil and could not be used in process.
	Emulsion Remover	48.0 ± 40.8 hrs (n=10)	1.0 ± 0.0 oz. (n=10)	2.9 ± 1.4 mins (n=10)	Low/ Moderate	Quickly, easily removed stencil.	
	Haze Remover	1.6 ± 0.8 mins (n=10)	1.2 ± 0.4 oz. (n=10)	12.2 ± 14.1 mins (n=10)	Moderate	30 min. wait time required caused scheduling problems at this facility.	
Laboratory Testing at SPTF							
SPTF Solvent-based Ink	*Ink Remover*	15 mins	2.5 oz.	6.7 mins	Low	Ink dissolved easily.	
	Emulsion Remover	24 hrs	0.5 oz.	6.4 mins	Low	Stencil dissolved easily; slight ink residue and light stain remaining.	
	Haze Remover	0 mins	1.0 oz.	5.6 mins	Low	Lightened stain slightly; removed residue.	
SPTF UV-curable Ink	*Ink Remover*	15 mins	2.0 oz.	5.5 mins	Low	Ink dissolved very easily.	
	Emulsion Remover	24 hrs	0.5 oz.	5.5 mins	Low	Stencil dissolved easily; dark ink stain remaining.	
	Haze Remover	0 mins	0.5 oz.	6.2 mins	Low	Lightened ink stain, but did not remove it.	

TABLE 6.22

COST ANALYSIS FOR ALTERNATIVE PHI

Description		Baseline	Alternative System Phi: Facility 5	Alternative System Phi: Facility 23
Facility Characteristics				
Average screen size (in^2)		2,127	2,815	883
Average # screens/day		6	3	4
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, and removing reclamation products (min)	24.4	8.0	22.0
	Cost ($)	$5.33	$1.74	$4.81
Materials and Equipment	# of rags used	3	2.9	1.3
	Cost ($)	$0.45	0.43	0.19
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	1.3	2.0
	Cost ($)	$0.22	0.25	0.39
	Emulsion Remover Average Volume (oz.)	3.5	1.7	1.0
	Cost ($)	$0.13	0.33	0.19
	Haze Remover Average Volume (oz.)	3.0	1.1	1.2
	Cost ($)	$0.12	0.35	0.37
Hazardous Waste Disposal	Amount (g)	34	0	0
	Cost ($)	$0.02	0	0
Totals				
Total Cost/Screen		$6.27	3.11	5.96
Normalized*		$6.27	6.10	7.82
Total Cost/year		$9,399	1,991	5,957
Normalized*		$9,399	9,233	11,728

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

PRODUCT SYSTEM ZETA

For Product System Zeta, this section describes the performance results from the laboratory performance tests and from the volunteer facility demonstrations, and also presents two tables: one summarizes the performance results and the other presents costing data. For information on the operating conditions of the three volunteer printing facilities where Product System Zeta, was demonstrated, or on the specific details of the product system performance at each of the facilities, see Appendix I.

Product System Zeta consisted of an ink remover, emulsion remover, and a haze remover. The performance of the products was demonstrated at Facilities 6, 7, and 15. Facility 6 prints store displays, traffic markings, and movie posters; Facility 7 prints decals, labels, vehicle markings, and store displays; Facility 15 prints plexiglass displays, store displays, and banners. During the demonstration period, Facility 6 reclaimed seven screens, Facility 7 reclaimed four screens, and Facility 15 reclaimed eight screens. Facility 6 used solvent, UV-cured, and water-based inks; Facility 7 and Facility 15 used solvent-based and UV-cured inks, and capillary film emulsions.

Performance in the Laboratory

Product System Zeta was tested at SPTF on three screens (one with a solvent-based ink, one with a UV-cured ink, and one with a water-based ink). The ink remover performance varied depending on the type of ink used. The emulsion remover and haze remover performance was consistent for all three screens.

On all three screens, the modifications were made to the manufacturer's instructions for applying ink remover. First, the technician applied the ink remover following the recommended method (spray on both sides of the screen, wait two minutes, squeegee off ink, and rinse with pressure washer). This application method did not satisfactorily remove the ink from any of the three screens. To improve the ink remover performance, the technician reapplied the product using a different method. For the second ink remover application, the technician wiped the screen with a dry rag to remove excess water, sprayed more ink remover over the entire screen, and wiped with rags until the rag was no longer picking up the ink. On the screen with solvent-based ink, the screen had some spots of ink residue and a medium gray haze after the first ink remover application. The stencil was affected in the half-tone area and it turned a light blue color in some areas. A second application of ink remover on the solvent-based ink screen removed the ink residue, but the stencil color came up on the rag. Four rags were used. On the screen with the UV ink, after the first ink remover application procedure, there was a heavy gray stain over the entire screen, ink residue remained in some areas, and the stencil had a dull finish. After the second application of the ink remover, the screen still had some ink stains remaining, but the gray haze was removed. Three rags were used. On the water-based ink screen, after the first application of ink remover was squeegeed off, ink residue remained, mainly on the emulsion. The ink wiped off easily when the ink remover was applied again. The rag was blue with the emulsion from the half-tone areas. Two rags were used.

On all three screens, the stencil dissolved easily with moderate scrubbing. A moderate ink stain remained on all of the screens, but there was no stencil stain or ink residue. The haze remover did not appear to lighten the ink stain on any of the screens. The technician also noted that the odor of the haze remover was so strong, she felt an exhaust fan or a respirator was required. Overall, although an ink stain remained on the screens, SPTF did not think the stain would affect future print quality and therefore, evaluated the product system as acceptable.

Summary of Performance at the Volunteer Facilities

This section summarizes the product system performance as recorded by the printers using the products at both of the demonstration facilities. The table at the end of the section summarizes both the field demonstration performance data and the results of the product tests performed at SPTF.

Ink Remover: Facility 6 reported that the performance of the alternative ink remover was poor, and they had to reclean their screens using their standard ink remover after the alternative product. Although the ink remover performed poorly with solvent and UV-cured inks in general, Facility 6 reported that the alternative ink remover worked well on one screen with water-based inks and on one with UV-cured ink. Facility 7 reported that for solvent-based inks, the ink remover seemed to dry on the screen and did not take the ink out; the alternative product did work well with UV-cured inks. To improve performance of the ink remover, the screen reclamation employee needed to begin wiping the ink remover off the screen immediately after spraying instead of waiting, as recommended. If the ink remover was not wiped off immediately, it dried on the screen and then they needed to use their regular ink remover. Facility 15 reported that the ink remover did not work at all for this facility; it had to be applied a number of times and, even with more scrubbing than usual, it had to be followed with their standard product.

Emulsion Remover: Both Facility 6 and Facility 7 found the emulsion remover did not work well when diluted with five parts water. When the facilities increased the emulsion remover concentration by diluting with only three parts water, the emulsion remover dissolved the stencil. At Facility 6, the performance of the emulsion remover was not consistent, even at the stronger concentration. Facility 7 was generally pleased with the performance of the emulsion remover at the stronger concentration, however, they still had problems if the emulsion remover was permitted to dry in the mesh. Facility 15 reported that the emulsion remover was passable, but the facility still preferred their own product. The alternative emulsion remover required extra scrubbing effort (even at full strength) at Facility 15.

Haze Remover: All three facilities reported that the haze remover did not have any effect on the haze. They all had to use their own haze remover in many cases. These facilities did not reclaim many screens using the Product System Zeta for several reasons: they were disappointed and discouraged by the early results, the products arrived later then expected and the observer was not present to assist the printers with the application procedure or to offer suggestions for improving performance, and the production schedules of the shops was unusually busy. Because of these factors, none of the facilities put extensive effort into attempting to alter application techniques to make the products work at their shop.

TABLE 6.23: PRODUCT SYSTEM ZETA PERFORMANCE

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
In-field Demonstrations at Volunteer Printing Facilities							
Facility 6 *Solvent-based, UV ink, and water-based inks* *Average screen size = 3926 in²*	*Ink remover*	24.0 ± 15.2 hrs (n=6)	8.3 ± 8.2 oz. (n=6)	2.8 ± 1.3 mins (n=6)	Moderate	Ink residue in screen.	• Only 7 screens were reclaimed at this facility. • They did not use the products because of poor performance.
	Emulsion Remover	12.0 ± 13.8 hrs (n=4)	6.5 ± 2.5 oz. (n=4)	4.8 ± 3.8 mins (n=4)	Moderate/ High	Worked well sometimes, but inconsistent results.	
	Haze Remover	11.5 ± 2.5 mins (n=4)	2.8 ± 1.0 oz. (n=4)	2.2 ± 0.5 mins (n=4)	Moderate	Seemed to have no effect on haze.	
Facility 7 *Solvent-based and UV inks* *Average screen size = 3060 in²*	*Ink remover*	3.6 ± 1.0 mins (n=4)	8.5 ± 4.5 oz. (n=4)	4.8 ± 1.3 mins (n=4)	Moderate	Dried into the screen mesh and did not remove ink effectively.	• Only 4 screens were reclaimed at this facility. • They did not use the products because of poor performance.
	Emulsion Remover	3.8 ± 7.5 hrs (n=4)	1.3 ± 0.5 oz. (n=4)	1.2 ± 0.5 mins (n=4)	Low	Reapplication of product needed to remove stencil.	
	Haze Remover	0.0 ± 0.0 mins (n=4)	2.0 oz. (n=1)	15.0 mins (n=1)	High	Seemed to have no effect on haze.	
Facility 15 *Solvent-based and UV inks* *Average screen size = 2084 in²*	*Ink remover*	10.2 ± 21.1 hrs (n=5)	3.0 ± 0.9 oz. (n=6)	6.2 ± 5.3 mins (n=6)	Low	A lot of product was required to remove the ink.	• This facility had to use their standard products before the screens could be reused. • They only reclaimed 8 screens before dropping out of the performance demonstrations.
	Emulsion Remover	13.3 ± 21.5 hrs (n=8)	4.1 ± 2.7 oz. (n=8)	6.5 ± 4.0 mins (n=8)	High	Stencil dissolved slowly with extra scrubbing effort.	
	Haze Remover	1.5 ± 2.0 mins (n=6)	2.3 ± 0.5 oz. (n=6)	20.2 ± 14.9 mins (n=6)	Moderate	Seemed to have no effect on haze.	

(continued)

TABLE 6.23 (continued)

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Performance for Each System Component	Overall System Performance
Laboratory Testing at SPTF							
SPTF Solvent-based Ink	*Ink Remover*	15 mins	2.5 oz.	6.0 mins	High	2 applications required to remove ink; stencil deteriorated in areas.	
	Emulsion Remover	24 hrs	1.0 oz.	4.3 mins	Moderate	Stencil dissolved easily; some ink stain left.	
	Haze Remover	0 mins	1.0 oz.	16.6 mins	Low	Did not appear to lighten haze at all; strong odor.	
SPTF UV-curable Ink	*Ink Remover*	15 mins	1.0 oz.	4.6 mins	High	2 applications required to remove ink; stains in some spots.	
	Emulsion Remover	24 hrs	1.5 oz.	4.5 mins	Moderate	Stencil dissolved easily; some ink stain left.	
	Haze Remover	0 mins	1.0 oz.	17.3 mins	Low	Did not appear to lighten haze at all; strong odor.	
SPTF Water-based Ink	*Ink Remover*	15 mins	1.5 oz.	5.7 mins	High	2 applications required to remove ink; stencil deteriorated in areas.	
	Emulsion Remover	24 hrs	1.5 oz.	4.5 mins	Moderate	Stencil dissolved easily; some ink stain left.	
	Haze Remover	0 mins	1.0 oz.	16.9 mins	Low	Did not appear to lighten haze at all; strong odor.	

TABLE 6.24

COST ANALYSIS FOR ALTERNATIVE SYSTEM ZETA

Description		Baseline	Alternative System Zeta		
			Facility 6	Facility 7	Facility 15
Facility Characteristics					
Average screen size (in^2)		2,127	3,926	3,060	2,084
Average # screens/day		6	13	11	5
Cost Elements per Screen					
Labor	Time spent applying, scrubbing, and removing reclaim products (min)	24.4	17.6	21.0	32.8
	Cost ($)	$5.33	3.85	4.59	7.18
Materials, Equipment	# of rags used	3	0.0	3.8	0.0
	Cost ($)	$0.45	0.00	0.56	0.00
Reclamation Product Use	Ink Remover Average Volume (oz.)	8.0	8.3	8.5	3.0
	Cost ($)	$0.22	1.50	1.53	0.54
	Emulsion Remover Average Volume (oz.)	3.5	6.5	1.3	4.1
	Cost ($)	$0.13	0.23	0.04	0.15
	Haze Remover Average Volume (oz.)	3.0	2.8	2.0	2.3
	Cost ($)	$0.12	0.64	0.47	0.55
Hazardous Waste Disposal	Amount (g)	34	115	90	61
	Cost ($)	$0.02	0.08	0.07	0.04
Totals					
Total Cost/Screen		$6.27	6.31	7.26	8.46
	Normalized*	$6.27	5.39	6.51	8.99
Total Cost/year		$9,399	19,704	19,973	9,521
	Normalized*	$9,399	8,080	9,772	13,479

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

ALTERNATIVE SCREEN RECLAMATION TECHNOLOGY THETA

The performance of the Alternative Technology Theta was demonstrated at Facility 1 under conditions similar to those used at SPTF for alternative product system testing. This facility, however, demonstrated the performance of an alternative screen reclamation technology, instead of an alternative chemical system. The alternative technology demonstrated was a high pressure water wash system with a 3000 psi spray applicator. When reclaiming screens with this high pressure washer, an emulsion remover and a haze remover are used, but no ink remover is needed. Several different types of emulsion and haze removers are sold with this technology. The performance demonstration was conducted using the chemical products that are normally used by this volunteer facility which are supplied by the System Theta equipment manufacturer. Therefore, this performance evaluation of this technology is based only on those chemicals used in the testing.

During the demonstration, the ink was carded off on both sides of the screen which caused some complications during testing. Since the screen was prepared specifically for the demonstration and was not actually used for printing, the ink on the stencil side transferred through to the print side when the screen was carded. To remove this excess ink, the print side was also scraped. The ink on the print side of the screen was more difficult to remove and this ink also made it harder to remove the emulsion. Under normal printing operations, ink does not reach the print side of the screen, therefore some of the difficulty caused by the ink on both sides of the screen would not occur. During the demonstrations, System Theta efficiently and effectively clean the screen, while reducing the labor, effort, and quantity of chemicals required for reclamation.

Summary of System Theta Performance Evaluation

Alternative Screen Reclamation Technology Theta was demonstrated using three screens; one with a solvent-based ink, one with a UV-cured ink, and one with a water-based ink. Results on the demonstrations are detailed here and are summarized in the table following this section. Test screens were prepared using the same parameters as were used for the testing of alternative chemical systems (these parameters are listed in the appendix). At the printing facility, the inks were applied to the stencil side of the screen, and excess ink was carded off (on both sides of the screen). Inks were allowed to dry for 18 hours before reclamation. The ink residue on both sides of the screen does not accurately represent the conditions in typical printing operations, however, it does represent a worst case condition.

On the screen with the solvent-based ink and the screen with water-based ink, the stencil dissolved easily with the application of the high pressure water; no scrubbing was needed. There was no emulsion or ink residue left in the screen, but there was a medium ink stain remaining on the screen with solvent-based ink and a very light stain on the water-based ink screen. On both screens, all of the ink and stencil did dissolve after less than four minutes of washing with the high pressure sprayer, however, the areas of the emulsion where the ink was on the print side of the screen did not dissolve as quickly as the areas where there was no ink on the print side. The haze remover completely eliminated the stains.

When the haze remover was applied, the product immediately dissolved the ink stain, even before the waiting period or the pressure wash.

Results were similar for the screen with UV ink. In most areas the stencil dissolved very easily without any scrubbing. After 4 minutes of water blasting, emulsion was still present in blocks where the ink was scraped on the print side of the screen. It is possible that the residual emulsion was caused by the test conditions and that it did not indicate poor performance on the part of System Theta. Some ink stain was remaining, especially in areas where the emulsion was left. The haze remover removed all of the ink, leaving only a very light stain, but the emulsion was still remaining in approximately one-third of the blocks. To remove the emulsion, the emulsion remover was reapplied and allowed to sit for 20 seconds. After water blasting the screen again, the emulsion was completely removed.

Overall, System Theta was an efficient and effective technique for screen cleaning. Use of the system could minimize the quantity of chemicals needed for screen reclamation by eliminating the ink remover and by using the high water pressure to reduce the quantity of emulsion and haze remover required. System Theta also reduces the labor time and effort needed to reclaim a screen.

TABLE 6.25: ALTERNATIVE SCREEN RECLAMATION TECHNOLOGY THETA

	System Component	Avg Drying Time Before Using Product	Average Quantity Applied	Average Cleaning Time	Average Effort Required	Overall System Performance
SPTF Testing at Volunteer Facility 1 *Average screen size = 360 in^2*						
SPTF Solvent-based Ink	*Ink and Emulsion Remover*	18 hrs	0.5 oz.	2.7 mins	Low	Removed stencil completely without scrubbing; where ink was put on print side of stencil, emulsion was more difficult to remove.
	Haze Remover	0 mins	1.5 oz.	1.7 mins	Low	Screen very clean; virtually no stain remaining.
SPTF UV-curable Ink	*Ink and Emulsion Remover*	18 hrs	1.0 oz.	5.5 mins	Low	Removed most of the stencil easily without scrubbing; where ink was scraped onto print side of screen, stencil residue remained.
	Haze Remover	0 mins	1.5 oz.	1.5 mins	Low	No ink residue, and very light stain. Parts of emulsion remained; a second application of emulsion remover was needed.
SPTF Water-based Ink	*Ink and Emulsion Remover*	18 hrs	1.0 oz.	3.3 mins	Low	Removed stencil completely without scrubbing; where ink was put on print side of stencil, ink was more difficult to remove.
	Haze Remover	0 mins	1.5 oz.	1.5 mins	Low	Screen very clean; virtually no stain remaining.

TABLE 6.26

COST ANALYSIS FOR HIGH PRESSURE WASHER THETA

Description		Baseline	Description	System Theta Facility 1
Facility Characteristics				
Average screen size (in^2)		2,127	Average screen size (in^2)	360
Average # screens/day		6	Average # screens/day	13
Cost Elements per Screen				
Labor	Time spent applying, scrubbing, removing reclamation products (min)	24.4	Time spent pressure washing, applying, and removing reclamation products (min)	5.4
	Cost ($)	$5.33	Cost ($)	$1.18
Materials and Equipment	# of rags used	3	Pressure Wash Equipment	
	Cost ($)	$0.45	Cost ($)	0.25
Reclamation Product Use	Ink Remover		Water Use (gal.)	10.7
	Average Volume (oz.)	8.0	Electricity Use (kWhr)	0.65
	Cost ($)	$0.22	Utility Cost ($)	0.11
	Emulsion Remover Average Volume (oz.)	3.5	Emulsion Prep Product Average Volume (oz.)	0.8
	Cost ($)	$0.13	Cost ($)	0.11
	Haze Remover Average Volume (oz.)	3.0	Haze Remover Average Volume (oz.)	1.5
	Cost ($)	$0.12	Cost ($)	0.36
Hazardous Waste Disposal	Amount (g)	34	Amount (g)	0
	Cost ($)	$0.02	Cost ($)	0
Totals				
Total Cost/Screen		$6.27	Total Cost/Screen	2.02
Normalized*		$6.27	Normalized*	4.53
Total Cost/year		$9,399	Total Cost/year	6,315
Normalized*		$9,399	Normalized*	6,797

* Normalized values adjust product usage, number of screens cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

ALTERNATIVE SODIUM BICARBONATE RECLAMATION TECHNOLOGY

The sodium bicarbonate screen reclamation technology consists of an enclosed spray cabinet where pressurized sodium bicarbonate (baking soda) and water are sprayed onto the parts inside the cabinet to clean them. Currently, this technology is used primarily for removing coatings, such as paint, grease, or teflon from metal parts, however, as part of the DfE Performance Demonstration, this technology was tested to determine if it is potentially adaptable as an alternative screen reclamation technology. Prior this project, the sodium bicarbonate technology was never tested for screen reclamation applications. The cleaning procedure used during the test was the method developed for cleaning metal parts and was adapted to screen reclamation where the screen was placed inside the enclosure and held under the pressurized baking soda spray to remove the ink, emulsion and haze from the screen simultaneously. The advantage of such a system for screen reclamation is that no hazardous chemicals are used, and the need for ink remover, emulsion remover, and haze remover is eliminated. In preliminary testing, the sodium bicarbonate technology showed potential for effectively removing solvent- or water-based inks. Results on a screen with UV ink, however, were poor. In all cases, further development and testing are needed before the technology could be used in a screen printing facility.

Sodium Bicarbonate-Based Screen Reclamation Technology Application Method

At this time, the sodium bicarbonate-based technology has not been developed specifically for screen reclamation. It has been successful in replacing hazardous cleaning chemicals in other applications such as in metal parts degreasing and paint and adhesives removal. To determine if this technology could be adapted for screen reclamation, three screens were prepared for cleaning: one with solvent-based ink, one with UV-cured ink, and a third screen with water-based ink. All tests were conducted at the equipment manufacturer's facility. This particular manufacturer developed the enclosed spray cabinet, and is a distributor of the sodium bicarbonate. Because this technology is still under development and is unproven for screen reclamation, no demonstrations were conducted at printing facilities. An observer from the DfE project was present to record information on the system's performance in cleaning the three test screens.

Tests were conducted in two different enclosures. Half of each screen was first cleaned in an enclosure which delivered dry, pressurized baking soda to the screen. The second half of each screen was cleaned in an enclosure which delivered both pressurized water and baking soda. The same cleaning procedure was used for the two systems. After excess ink was carded off, the screen was placed inside the enclosure with the flat side down. The door was locked and the operator placed his hands through the gloves built into the box. By stepping on the foot pedal, the operator started the flow of pressurized sodium bicarbonate from the fan nozzle mounted in the top of the enclosure. The fan nozzle, designed by the enclosure manufacturer, spreads out the impact of the sodium bicarbonate to reduce the stress on the screen. The nozzle used for testing dispersed the sodium bicarbonate over an area approximately one inch wide by three inches long. On the wet system, the same nozzle was used to deliver the sodium bicarbonate, and the water nozzle was mounted on the fan nozzle, so that the water and baking soda mixed together as they were discharged. Holding the screen under the fan nozzle, the operator moved the screen from side to side. The operator was able to see where the ink or emulsion remained on the screen by watching through the primary viewing area. This window was purged with air to enhance visibility by clearing the dust from the viewing area. When the first side was clean, the operator flipped the screen over and repeated the cleaning procedure on the other side until all ink, emulsion, and haze were removed.

<u>Summary of Alternative Sodium Bicarbonate Technology Performance Results</u>

Cleaning without Water

During the demonstration, several different application methods were tested to optimize the system performance. First, the screen with solvent-based ink was cleaned in a dry box; only pressurized baking soda was delivered, without any water. At a pressure of 5 psi, some of the ink and emulsion were removed, but very slowly. A heavy haze and some ink and emulsion residue remained. To accelerate the removal, the pressure was increased to 10 psi. This pressure proved to be too high and the screen developed pin holes and eventually ripped. The pressure was reduced to 5 psi. To reduce the stress on the mesh, a flat plate was placed behind the screen. Screen damage was reduced, but was not eliminated.

Similar results were obtained with the water-based ink screen. Significant ink and emulsion residue remained on the screen after cleaning a 4 inch by 4 inch area for 5 minutes. Again, screen wear and small holes were visible in some areas. After these disappointing results, dry testing was discontinued in favor of the wet delivery system. The water serves to soften the sodium bicarbonate, making it less abrasive than the dry delivery process. Because of the softening effect, a higher pressure could be used with the wet delivery system without damaging the screen.

After such poor performance was demonstrated using the dry cleaning process on the solvent- and water-based ink screens, the decision was made to skip the dry process for the UV ink screen, and start with the wet cleaning process. Additionally, the UV ink does not dry (unlike the solvent- and water-based inks), and the manufacturer felt that the application of the dry sodium bicarbonate would stick to the wet ink across the entire screen, instead of removing the ink. If the sodium bicarbonate was covering the screen, the wet cleaning process test would not be valid.

Cleaning with Water

All three screens were tested using the wet process (cleaning with water). Water was sprayed onto the screen at 200 - 250 psi, while the sodium bicarbonate was sprayed out of a fan nozzle at varying pressures. On the screens where the dry process was used to clean half the screen, the wet process was used for the other half. Performance clearly improved using the wet technology.

On the screen with UV ink, the sodium bicarbonate-based technology was completely ineffective. After about 5 minutes of cleaning, there was almost no removal of the ink or the emulsion. The operator increased the pressure to 20 psi to improve the system performance. When there was no improvement at 20 psi, the pressure was increased to 30 psi. Even at the higher pressure, there was no significant removal of the ink or the emulsion from the screen. The operator put a glass plate behind the screen to concentrate the sodium bicarbonate and to support the screen, but this did not help to remove the ink or emulsion. After approximately 10 minutes of cleaning without any noticeable removal of ink, the test was stopped.

The solvent-based ink screen was cleaned first. At 5 psi, it took approximately 5 minutes to remove the ink and emulsion from a 4 inch by 4 inch area of the screen. At this point the screen was visually inspected. There was no visible damage to the screen, so the pressure was increased to 10 psi. Another 4 inch by 4 inch area was cleaned, and at 10 psi, it took approximately 3 minutes. Some areas of the emulsion came off in stringy pieces. After cleaning the rest of the screen, a light haze remained in the image area. Around the edges of the screen where the ink was fairly thick, a heavy residue remained, but there was no ink or emulsion residue in the image area. Total screen cleaning time for the half of the screen that was cleaned with the wet cleaning process (a 10 inch by 10 inch area), took approximately 16 minutes.

Performance on the screen with water-based ink was similar to the screen with solvent-based ink. On the water-based ink screen, all testing was conducted with the sodium bicarbonate pressure at 10 psi. Initially, the ink started to come off fairly well, but very slowly. After a few minutes, the ink began flaking off, instead of dissolving. The flaking made it significantly easier to remove the ink. Again, the emulsion came off in stringy rolls. Ink residue remained around the edges of the screen, but the image area was clean with a very slight haze. After closer inspection, some very small spots of ink residue were apparent. In an effort to remove these spots, the operator concentrated the spray on the small effected area. After one or two minutes, this concentrated pressure ripped the screen. Total cleaning time for the portion of the screen that was cleaned with wet cleaning (10 inches by 10 inches), was approximately 13 minutes.

Alternative Sodium Bicarbonate Technology Potential

The cleaning procedures used during testing were the methods used for cleaning metal parts and were not specifically developed for screen reclamation. With further testing and research, this application method could be improved to clean the screens faster and with less possibility for screen damage. For example, during the test, a piece of rigid material (safety glass) was held behind the screen to reduce the pressure on the mesh. From the limited testing performed, this support seemed to concentrate the cleaning media on the desired area while reducing the stress on the screen. As another change that may improve performance, the operator suggested using hot water. When cleaning the screens with solvent- and water-based ink, the emulsion came off in stringy pieces that rolled off the screen. This reaction did not seem to increase or decrease the removal efficiency, however, hot water may help dissolve the emulsion, potentially accelerating the removal process. A third possible improvement in the application technique may be to add a small platform inside the enclosure which would help the operator hold the screen closer to the spray nozzle.

In addition to equipment modifications, several other variable changes that may be specific to each facility should also be investigated. These factors include increasing or decreasing the particle size of sodium bicarbonate, changing the pressure of the water or the sodium bicarbonate, and changing the rate of delivery of the medium. With further research into improvements in the sodium bicarbonate application, this technology could potentially reduce chemical use during screen reclamation for printers using solvent-based or water-based inks.

APPENDIX A: FACILITY BACKGROUND QUESTIONNAIRE
Design for the Environment Screen Printing Project

1. *Business Profile*

a. Products
Approximately what percentage of your products are printed on the following substrates? (Please check all boxes that apply).

	<50%	50 - 95%	95 - 100%
Plastics (rigid/flexible)	☐	☐	☐
Paper (coated or uncoated)	☐	☐	☐
Metal	☐	☐	☐
Ceramic	☐	☐	☐
Glass	☐	☐	☐
Other (specify)	☐	☐	☐

b. Please list the major products produced at your facility:

____

____

____

____

c. Approximately what percentage of your shippable product, by sales dollars, is produced through screen printing? ____________________

d. Approximately how long is your typical run? ____________________

e. Approximately what percentage of your orders are repeat orders? __________

2. *Screen Reclamation Operations*

a. Screen Size: Specify the average size frame used at your facility:
_____________ *(ft² or in²)*

b. Tracking: Describe how your screens are tracked or numbered in the facility:

____

____

____

c. Volume:
What is the average number of screens cleaned/reclaimed each day for future use? (Please check the appropriate box)
0 - 5.....☐ 5 - 10.....☐ 10 - 15.....☐ >15.....☐ *(specify ______)*

d. Employees
Please fill in the table below. For the purposes of this questionnaire, "Ink Removal" is not defined as press-side operations, unless this is the only site used for ink removal. Assume a 5-day work week with one 8-hour shift each day. Please check all boxes that apply.

Number of Employees at this Location	Number of Employees Involved in Ink Removal	Number of Employees Involved in Screen Cleaning/Reclamation	Average time (hr/day) a single individual is involved w/ ink removal	Average time (hr/day) a single individual is involved w/screen cleaning/reclaiming
0 - 5 ☐	1 - 3 ☐	1 - 3 ☐	<1 ☐	<1 ☐
6 - 10 ☐	4 - 6 ☐	4 - 6 ☐	1 - 2 ☐	1 - 2 ☐
11 - 15 ☐	7 - 10 ☐	7 - 10 ☐	3 - 4 ☐	3 - 4 ☐
16 - 30 ☐	>11 ☐	>11 ☐	5 - 6 ☐	5 - 6 ☐
31 - 50 ☐			7 - 8 ☐	7 - 8 ☐
>50 ☐	specify ______	specify ______	other, specify ______	other, specify ______

e. Ink Removal and Screen Reclamation Areas
Do you have separate areas for ink removal and screen reclamation activities? ("Ink removal" is defined as activities after excess ink is carded off. It does not refer to ink removal activities *during* the process).
Yes.....☐ No.....☐

- If "yes", check all that apply in the first four columns of the table below.

- If "no", check all that apply in the last 2 columns of the table below.

Separate areas for ink removal and screen cleaning/reclamation activities				*Combined Ink Removal/ Screen Reclamation Areas*	
Ink Removal Area (ft^2)	**Type of Ventilation**	**Screen Reclamation Area (ft^2)**	**Type of Ventilation**	**Size of Combined Area (ft^2)**	**Ventilation**
<20 ☐	local (mechanical) ☐	<20 ☐	local (mechanical) ☐	<20 ☐	local ☐
20 - 50 ☐	plant ☐	20 - 50 ☐	plant ☐	20 - 50 ☐	plant ☐
50 - 100 ☐	natural ☐	50 - 100 ☐	natural ☐	50 - 100 ☐	natural ☐
100 - 200 ☐	other ☐ (specify):	100 - 200 ☐	other ☐ (specify):	100 - 200 ☐	other ☐ (specify):
>200 ☐ (specify): ________		>200 ☐ (specify): ________		>200 ☐ (specify): ________	

3. *Rates*

a. Record the electric rate: ______________

b. Record the water rate: ______________

c. Record the sewer rate: ______________

d. Record the screen reclamation employee's wage rate: ______________

e. Record the printer's wage rate: __________________ *(Use the rate for the printer who would determine if the print image quality is acceptable).*

4. ***Current Ink Remover Procedures*** (NOT process cleaning)

a. What type of ink(s) do you use?

____

____

b. Do you recycle ink removal products? Yes.....☐ No.....☐

- Do you recycle on-site or off-site?

- Do you use the recycled product in-house? Yes.....☐ No.....☐

If so, how much do you use annually? _________ gallons

- If recycled off-site, does the recycler sell the recycled product?

- What are the costs and income associated with recycling ink removal products?

c. On average, to how many screens/day is ink remover applied? ___________

d. Describe the current method of applying ink remover:

____

____

____

e. Do you use a pressure washer (or other equipment) for ink removal?

- If so, specify the type of equipment, manufacturer, and model (from nameplate):

- Specify the pressure (psi) and flowrate (gpm):

- What are the equipment energy use specifications (from nameplate):

- How long is it in use for each screen?

f. Fill in the table on the next page for each of your ink remover products.

Current Ink Removal Practices

Ink Removal Product (trade name and description)	Annual Volume of Product Purchased (gallons)	Cost of Ink Removal Product ($/gallon)	Type of Ink with which Product Works Best	Personal Protective Equipment Used	Method of Applying Ink Removal Product	Materials Used to Loosen Ink	Avg # of Rags Used/Screen to Remove Ink
			Solvent-based ☐ UV-Curable ☐ Water-based ☐ Any ☐	Gloves ☐ Eye Protection ☐ Aprons ☐ Respiratory protection ☐ Barrier Cream ☐ None Used ☐	Pour from container onto screen surface ☐ Dip rag or brush into container; wipe screen ☐ Spray on w/ nozzle from tank ☐ Spray on w/ spray bottle ☐ Use specialized spraying equipment (specify) ☐ Other (specify) ☐	Brush ☐ Squeegee ☐ Disposable rag ☐ Reusable rag ☐ Other (specify): ☐	0-2 ☐ 2-4 ☐ 4-6 ☐ 6-8 ☐ 8-10 ☐ Other (specify):

f. List the types of materials used in ink removal that are frequently replaced (such as brushes, squeegees, wipes and filters) and their costs. Note how often they are replaced and how much of your time does it take to order replacements?

____

____

____

____

____

____

5. *Current Emulsion Remover Practices*

a. Fill in the following information and the table below for each type of emulsion removal product you currently use:

Trade Name ______________________ Volume purchased in 1993 (gal.) __________

Generic product description __________________ Purchase Price ($/gal.) __________

Average # of screens/day where emulsion remover is applied: ______________________

Personal Protective Equipment Used	Method of Applying Emulsion Removal Product	Equipment or Materials Used to Remove Emulsion	Equipment or Materials Description *(Include manufacturer, model #, pressure (psi) and flow rate (gpm) if applicable, frequency of replacement, equipment energy requirements)*
Gloves ☐ Eye Protection ☐ Aprons ☐	Pour from container onto screen surface ☐ Dip rag or brush into container and wipe screen ☐	Brush ☐	
		Low pressure water spray ☐	
Respiratory protection ☐ Barrier cream ☐ Ear Protection ☐ None Used ☐ Other (specify): ☐	Spray on with nozzle from tank ☐ Spray on with spray bottle ☐ Use specialized spraying equipment (specify) ☐ Other (specify) ☐	High-pressure water spray ☐	
		Water-blaster ☐	
		Automatic Screen Cleaning System ☐	
		Disposable Rag ☐	
		Reusable Rag ☐	
		Other (specify): ☐	

6. *Current Haze Remover Practices*

a. Fill in the following information and the table below for each type of haze removal product you currently use:

Trade Name ____________________

Generic product description ____________________

Average % of screens reclaimed where haze remover is applied: ____________________

Volume purchased in 1993 (gal.) __________

Purchase Price ($/gal.) __________

Personal Protective Equipment Used	Method of Applying Haze Removal Product	Equipment or Materials Used to Remove Haze	Equipment or Materials Description *(Include manufacturer, model #, pressure (psi) and flow rate (gpm) if applicable, frequency of replacement, equipment energy requirements)*
Gloves ☐	Pour from container onto screen surface ☐	Brush ☐	
Eye Protection ☐	Dip rag or brush into container and wipe screen ☐	Low pressure water spray ☐	
Aprons ☐	Spray on with nozzle from tank ☐	High-pressure water spray ☐	
Respiratory protection ☐	Spray on with spray bottle ☐	Water-blaster ☐	
Barrier cream ☐	Use specialized spraying equipment (specify) ☐	Automatic Screen Cleaning System ☐	
None Used ☐	Other (specify) ☐	Disposable Rag ☐	
Other (specify): ☐		Reusable Rag ☐	
		Other (specify): ☐	

7. *Materials Storage*

a. Where do you store your ink removal and screen reclamation products and in what quantity? Please check one box for each column.

Storage Method	**How is ink removal stored in the application area?** *(check all that apply)*	**How is ink removal stored in the storage room?** *(check all that apply)*	**How is emulsion remover stored in screen cleaning area?** *(check all that apply)*	**How is emulsion remover stored in storage area?** *(check all that apply)*	**How is haze remover stored in the cleaning area?** *(check all that apply)*	**How is haze remover stored in storage area?** *(check all that apply)*
30- or 55-gallon drum with bung hole kept open	☐	☐	☐	☐	☐	☐
30- or 55-gallon drum with bung hole kept closed	☐	☐	☐	☐	☐	☐
30- or 55-gallon drum with top removed	☐	☐	☐	☐	☐	☐
Open pail	☐	☐	☐	☐	☐	☐
Closed pail	☐	☐	☐	☐	☐	☐
Quart or smaller squirt bottle	☐	☐	☐	☐	☐	☐
Safety can	☐	☐	☐	☐	☐	☐
Safety cabinet	☐	☐	☐	☐	☐	☐
Not kept in the press room	☐	☐	☐	☐	☐	☐
Other (specify)	☐	☐	☐	☐	☐	☐

8. Waste Disposal

a. Please indicate the quantity of waste you dispose of annually as <u>hazardous</u> waste for:

spent solvent waste: __________ (gal. in bulk) OR __________ (# of 55 gal. drums)

ink waste: __________ (gal. in bulk) OR __________ (# of 55 gal. drums)

used shop rag waste __________ (gal. in bulk) OR __________ (# of 55 gal. drums)

b. Ink Removal and Screen Cleaning Wastes

Fill in the table below to describe the treatment and disposal methods used for waste (not only *hazardous* wastes) generated by the ink removal and screen cleaning/reclamation operations:

Ink Removal Area Wastes			**Screen Cleaning/Reclamation Wastes**		
Quantity Generated Annually (gal)	**Method of Storage Prior to Treatment/ Disposal**	**Method of Treatment or Disposal**	**Quantity Generated Annually (gal)**	**Method of Storage Prior to Treatment/ Disposal**	**Method of Treatment or Disposal**
	In closed containers ☐	Filter or treat prior to disposal or recycle ☐		In closed containers ☐	Filter or treat prior to disposal or recycle ☐
	In open containers ☐	Send to recycler ☐		In open containers ☐	Send to recycler ☐
	No specified container ☐	Recycle on site ☐		No specified container ☐	Recycle on site ☐
	Other ☐ (specify):	Discharge to sewer ☐		Other ☐ (specify):	Discharge to sewer ☐
		Dispose as hazardous waste ☐			Dispose as hazardous waste ☐
		Dispose as non-hazardous waste ☐			Dispose as non-hazardous waste ☐
		Other (specify) ☐			Other (specify) ☐

9. Drying

a. Are screens dried between ink removal and emulsion removal?

- If yes, how are they dried? (air dried or dried with equipment such as fans, heater, etc.) - If drying equipment is used, note:
  - Duration of drying step:
  - Manufacturer and model of the equipment:
  - Energy use specifications:

b. Are screens dried between emulsion removal and haze removal?

- If yes, how are they dried? (air dried or dried with equipment such as fans, heater, etc.)
  - If drying equipment is used, note:
    - Duration of drying step:
    - Manufacturer and model of the equipment:
    - Energy use specifications:

APPENDIX B:

Observer's Evaluation Sheet

Facility name: ____________________ Location: ______________________

Date: ______ Facility contact name/phone: ______________________

Screen reclamation employees(s): ____

1. Type of Demonstration:

check one: Standard Products _____ Alternative Products _____

2. Operating Conditions

Record the information on the screen being cleaned on the table below:

Screen Information

SCREEN CONDITION	*Fill in the blank or circle the appropriate characteristic. Make any notes or comments in the space to the right.*
Screen identification and history	• *Enter the identification marking code that is on the screen:* • *Estimate the number of impressions printed over the life of this screen:* • *Estimate how much ink was left on the screen? (< avg., avg., > avg.)*
Screen size	______________ x ______________ (specify units; in^2 or ft^2)
# impressions of the last run	
Screen degreaser	• *Specify manufacturer and series # or name:*
Ink type	• *Circle one:* Solvent-based, UV, or water-based • *Specify manufacturer and series # or name:*
Ink color	• *Circle one:* Blue, Black, Other (specify):
Emulsion type	• *Circle one:* Capillary film, Direct photo stencil, Dual cured, Other (specify): • *Specify manufacturer and series # or name:*
Ink coverage	• *Check one:* 0 - 25%...☐ 25 - 50%...☐ 50 - 75%...☐ 75 - 100%...☐

Screen condition	*Note any rips, holes, corrosion*
Screen mounting	Is a retensionable frame used? Is the screen glued to the frame?
Thread count **Thread diameter**	______________ threads/inch ______________ (specify units)
Tension level *(measure both major axes; specify units)*	major axis: ______________________ N/cm minor axis: ______________________ N/cm
Mesh type *(record type of mesh material)*	
Mesh treatment *(has the mesh been abraded? calendared? or treated?)*	
Calibration of measurements	_______ scoop(s) of haze remover = _______ ounces
Temperature *(in the work area)*	• **Ink removal area:** ______________ °F • **Emulsion/Haze removal area:** ______________ °F
Humidity *(in the work area)*	• **Ink removal area:** ______________ % • **Emulsion/Haze removal area:** ______________ %

3. Cleaning Procedure

- Clean the screen using the application technique designated by SPTF for alternative products or follow your typical screen reclamation procedure if demonstrating the currently used products. Observe all actions taken by the employee in reclaiming the screen and record any differences between the technique used and the technique specified by SPTF for alternative products or the technique documented in the facility questionnaire for products currently used at the facility.

Cleaning Procedure:

____

____

____

____

- For currently used products, are any variations of the reclamation procedure used, and if so, under what circumstances? For what percentage of screens, or how often are these method variations used?

____

____

____

- Describe any temperature or humidity controls in the screen reclamation area.

____

____

____

4. Performance

Complete the performance evaluation table on the next page for alternative products and for currently used products.

Performance Evaluation

	Enter quantity, comments, and notes
Drying Time *(specify units; hours or mins.)*	• Time from end of press run to start of **ink removal** with product: ________ • Time from ink removal completed to start of **emulsion removal:** ________ • Time from emulsion removal completed to start of **haze removal:** ________
Dilution *(record dilution ratio or enter "None")*	• Ink Remover ________ *(enter ratio)* or *"none"* • Emulsion Remover ________ *(enter ratio)* or *"none"* • Haze Remover ________ *(enter ratio)* or *"none"*
Quantity of Product Used	• Ink Remover ________ *(enter # of ounces)* • Emulsion Remover ________ *(enter # of ounces)* • Haze Remover ________ *(enter # of ounces or scoops)*
Time to clean *(do not include screen positioning or equipment clean up time)*	• Ink Remover ________ *minutes* • Emulsion Remover ________ *minutes* • Haze Remover ________ *minutes*
Physical effort required *(circle one for each step and describe effort used)*	• Ink Remover: *circle one:* Low, Moderate, High. *Describe:* • Emulsion Remover: *circle one:* Low, Moderate, High. *Describe:* • Haze Remover: *circle one:* Low, Moderate, High. *Describe:*
If wipes were used for ink removal, specify the type, size and quantity used.	
Was a pressure washer used? *(check one for each step)*	• For Ink Removal: No ____ Yes ____ (specify length of time used ______ mins.) • For Emulsion Removal: No ____ Yes ____ (specify length of time used ______ mins.) • For Haze Removal: No ____ Yes ____ (specify length of time used ______ mins.)

Was tap water (NOT pressure wash) used in any part of screen cleaning/reclamation?	Was (non-pressurized) water used in *(check all that apply)*: Ink Removal...☐ or Emulsion Removal...☐ or Haze Removal...☐ Flowrate: ____________________(gallons/minute) Length of time used: ____________________(specify seconds or minutes)
Examine screen after ink removal.	• Did the product effectively and easily remove the ink? Also note any side effects of the product on the mesh):
Examine screen after emulsion removal.	• Is there any ink haze or stencil stain on the mesh? If so, describe in detail: • If any emulsion is still present, describe the residue left on the screen in detail: • Note any side effects on the screen *(e.g., mesh damage, corrosion, etc.)*
Examine screen after reclamation is complete.	• Can the screen be reused for all jobs? *(check one)* Yes _______ No_______ If "No", describe why the screen cannot be reused or what limitations apply: *(e.g., Is there is a ghost image? Can the screen be used for reverse printing? for close tolerance work? Can transparent inks be used with it?)*
Remeasure the screen tension *of both major axes and record (specify units)*	• major axis: ________________N/cm • minor axis: ________________N/cm
Examine the substrate image after the screen is reused. Comment on the print image quality.	
Comments or suggestions - Use the back of this sheet to note anything unusual about this demonstration. (e.g., did you have to reapply any of the products? was this screen more difficult to clean than others?)	

5. Experience with Alternative Screen Reclamation Products

a. Have you tried any alternative chemical products to replace your current screen reclamation products?

- If yes, please list the product trade name(s) and the generic product type(s):

____

____

____

- Why were the alternative product(s) better, the same, or worse than your old product?

____

____

____

- If you have not tried a different chemical product, please check the box that best describes your reason for not trying alternatives:

Lack of adequate information to evaluate environmental performance:	☐
Operators do not believe alternatives will work:	☐
Not impressed with product descriptions:	☐
Cost is prohibitive:	☐
Other: (please explain):	☐

b. Besides alternative chemical products, have you implemented any changes in equipment, procedures or work practices that reduced your use of screen reclamation chemicals, or reduce the time, effort or water required to use those products? Yes.....☐ No.....☐

- If yes, please describe:

____

____

____

c. Does this facility have a pollution prevention, waste minimization, or source reduction program?

- If yes, please describe:

____

____

APPENDIX C:

Ink Remover Evaluation Sheet for Printers

Facility name and Location: ____

Date: __________ **Ink Remover employee's name:** ______________________

Answer the following questions regarding screen condition and alternative product performance:	
Screen identification and history	• *Enter the identification marking code for the screen:* • *Estimate how much ink was left on the screen?*
Screen size	________ inches x ________ inches
Screen condition and threads per inch	• *Note screen condition including any rips, holes, corrosion:* • *Record the screen mesh size:* ____________threads/inch
Mesh	• *Mesh material type:* • *Mesh treatment:*
# impressions of the screen's last run	
Ink type	• *Circle one:* Solvent-based, UV, Water-based • *Specify manufacturer and series #:*
Ink color	• *Circle one:* Blue, Black, Other (specify):
Emulsion type	• *Circle one:* Capillary film, Direct photo, Dual cure, Other: • *Specify manufacturer and series #:*
% Ink Coverage	• *Check one:* 0-25%..☐ 25-50%..☐ 50-75%..☐ 75-100%..☐
Drying Time	Time from end of press run to start of ink removal ______
Ink Remover Dilution	____________ *(enter ratio)* or *"none"*
Quantity of Ink Remover	____________ oz.
Time	*Enter time from application of ink remover product until screen is ready for the next step:* ____________ mins.
Physical effort required	*(circle rating and comment)* Low, Moderate, High
How many wipes did you use?	
Was a pressure washer used?	*(check one)* Yes ______ No______
Examine screen after ink removal.	*Did the ink remover effectively and easily remove the ink? (Also note any side effects of the product on the screen)*
Comments or suggestions - Record any comments and note anything unusual about the reclamation on a separate sheet of paper. (e.g., did you have to reapply the product? why was the screen hard to clean?)	

APPENDIX D:

Emulsion Remover Evaluation Sheet for Printers

Facility name and location: ______________________________

Date: ________ Screen Reclamation employee's name: ______________________

Fill in the blank/circle the appropriate answer. Make any notes or comments in the space to the right.	
Screen Identification	• *Enter the identification marking (tracking) code for the screen:*
Drying Time *(Specify units; hours or mins.)*	• Time from ink removal completed to start of emulsion removal: ________ • Time from emulsion removal completed to start of haze removal: ________
Dilution	• Emulsion Remover ________ *(ratio)* or *none* • Haze Remover ________ *(ratio)* or *none*
Quantity of Product Used	*Enter # of ounces used:* • Emulsion Remover ________ ounces • Haze Remover ________ ounces
Product Use Time	*Enter time from application of product until screen is ready for the next step* • Emulsion Remover ________ mins. • Haze Remover ________ mins.
Was a pressure washer used?	• For emulsion removal? *(check one)* Yes ______ No______ • For haze removal? *(check one)* Yes ______ No______
Physical effort required *(circle one for each step and describe the level of effort)*	• **Emulsion Remover:** *circle one:* Low, Med., High; *Describe if the stencil dissolved easily or slowly, and if a great deal or very little scrubbing took place:*
	• **Haze Remover:** *circle one:* Low, Med., High; *Describe the effort required for haze removal:*
Examine screen after emulsion removal.	• **Is there any ink haze or stencil stain on the mesh? If so, describe:** • **If any emulsion is still present, describe the residue left on the screen in detail:**
Examine screen after reclamation is complete.	• Can the screen be reused for all jobs? Yes ____ No____ If "No", describe why the screen cannot be reused: *(e.g., Is there a ghost image? Can the screen be used for reverse printing? Can it be used for close tolerance work? Can transparent inks be used with it?)*
Examine the substrate image after the screen is reused.	**Comment on the print image quality:**
Comments - Record any comments and note anything unusual about the reclamation on a separate sheet. (e.g., did you have to reapply the product? why was this screen more difficult to clean?)	

APPENDIX E:
Weekly Follow-up Call to Screen Printers
in the DfE Performance Demonstration Project

Once a week, the observer will contact the facility by phone. This form is to guide the conversation, but let the printer discuss any problems, changes or concerns. ***Remind them to send in the envelope with this week's forms.***

1. In your opinion, is the performance of the alternative products better, worse or about the same as the products you used before this demonstration? Why?

____

____

____

2. Have you found any conditions where the products did not work? (e.g., is there any ink type or emulsion type where the product did not work?) If so, describe the condition(s).

____

____

____

3. Have you found any conditions (ink type, emulsion type, etc.) where the products work particularly well? If so, please describe the condition(s).

____

____

____

4. Have you changed the application procedure in any way to improve product performance? If so, please describe. For example,

- do you apply the product to the screen sooner?
- do you let the product sit/soak on the screen longer?
- have you used a different type of brush? or scrubber? or wipe?

____

____

____

5. Have you tried any different application techniques that did <u>not</u> improve performance?
- What did you change? • Why did you make the change?
- Was product performance worse after the change? How?

____

____

6. Have you changed the quantity of product you use? Why?

____

____

7. How are you timing how long you use each product? (i.e., are you *estimating* the time or are you actually timing it?)

____

____

8. What measurement method are you using? Are you still using the same spray bottle and the same scoop provided?

____

____

9. Do you think the screen failure rate has increased, decreased or remained the same as a result of using the new product? What signs have you seen that suggest the failure rate may differ?

____

____

10. Do you have any other comments or concerns regarding the alternative products?

____

____

APPENDIX F: Methodology Used in the Screen Reclamation Performance Demonstrations

Note: This methodology incorporates comments from discussions with the Screen Printing Technical Foundation, the Screen Printing Association International, screen printers, and manufacturers and suppliers of screen reclamation products and equipment.

I. PERFORMANCE DEMONSTRATION OVERVIEW

A. Goal

The objective of this performance demonstration is twofold: (1) to obtain specific information from printing facilities concerning the performance of commercial chemical and mechanical screen reclamation systems; (2) to encourage printers to experiment with new products and work practices that reduce human health and environmental risk. This data will be incorporated into the Cleaner Technologies Substitutes Assessment.

B. General Plan

The majority of printers participating in the performance demonstration will evaluate the effectiveness of one manufacturer product line/system for screen reclamation, using a method that includes the use of ink remover, emulsion remover and haze remover products in screen reclamation. Each facility will be responsible for reclaiming screens over a thirty-day period, utilizing the specified product system. The performance of one or two substitution processes relying on specially equipped mechanical and/or chemical reclamation cleaning systems will be demonstrated, including: (1) high-pressure water blaster; (2) sodium bicarbonate reclaim system.

C. Desired Characteristics to be Reported from Performance Demonstrations

1. **Actual cost of chemical product or reclamation equipment**
   Definition: Cost per volume used per area of screen cleaned (ft^2).

   We will ask that product manufacturers include the average purchase price of their individual products (haze remover, stencil remover, ink remover, reclamation equipment) when the product/equipment is submitted for the performance demonstration. The adjusted or actual cost of screen reclamation products will be determined through incorporation of product purchase price, product application cost, labor costs, and safety and disposal costs.

2. **Product constraints**

<u>Example</u>: Whether the product category (e.g. ink remover) is incompatible with certain types of inks

This information should be submitted by the manufacturers and may also be discovered as a result of the performance testing. If the manufacturer does not provide any information regarding product incompatibilities, we will assume that there are no incompatibility concerns.

3. **Special storage, safety and disposal requirements**

<u>Examples</u>: Flammability or volatility of the product

This information will be requested on the manufacturer questionnaire and will vary according to the chemicals comprising the products/equipment to be submitted. We will ask that manufacturers provide recommendations on disposal or treatment of wastes associated with the use of their products. The storage costs will be a factor in determining the adjusted cost of the product.

4. **Ease of use**

<u>Definition</u>: The physical effort required to effectively clean the screen using the test product

This is a subjective standard based on the judgment of the screen cleaner and printer. As a frame of reference, the screen reclamation employee or facility point-of-contact will be asked to describe their current work practices for screen reclamation and the physical effort required with their current system. When the performance information is tabulated for each manufacturer system demonstrated at a facility, the data regarding the products currently used at the facility will also be noted.

5. **Duration of the Cleaning Cycle**

<u>Definition</u>: The measured time of the screen cleaning process (e.g. beginning with the application of ink removal product to the screen until the final water wash is completed)

This will attempt to measure the labor costs associated with the use of the products. Labor costs will be based on the time required for the screen reclamation with the specific products and a standard screen cleaning wage.

6. **Physical/Chemical properties of the screen reclamation system**

<u>Definition</u>: Characteristics associated with use of the individual system, such as chemical components or pressure at which chemicals are applied.

The chemical components of each product system must be submitted by each manufacturer participating in the demonstration project. The physical characteristics of each system as used, including such factors as water pressure as applied and type of specialized equipment used, will be documented.

7. **Effectiveness of the screen reclamation system**

This is a subjective criteria and depends on the judgment of the printer and the employee reclaiming screens at the facility. They will examine the screen after the reclamation process is complete and answer two questions: (1) Can this screen be reused for general screen printing purposes?; (2) Can this screen be used to print a reverse image? These questions will not be answered solely on the basis of the screen appearance. When the screen is reused for printing, any problems with ghost images or weak screens will be documented.

8. **Screen, stencil and ink information**

The majority of screens reclaimed in the demonstration project should have a monofilament polyester mesh with a nominal thread count in the range of 230-390 Mc/in. However, if the screen mesh thread count is outside of this range, the data will be documented. Data recorded for each screen reclaimed should include threads per inch, the age of the screen and the prior printing history of the screen. The length of time between the end of the press run and the actual screen reclamation should be estimated. The color and type of ink, and the type of emulsion will also be reported. If possible, the tension level (N/m) of the screen should be recorded. The condition of the screen (rips, tears) before and after the test will be reported. The printing performance of the screen after it has been reclaimed will also be documented. This descriptive information serves two purposes: (1) it provides data to determine the specific effectiveness of the methods and various product lines; (2) it may assist in discovering and reporting incompatibilities between the products and types of inks and emulsions.

II. METHODOLOGY FOR ON-SITE PERFORMANCE DEMONSTRATION

A. Selection of Products for the Performance Demonstration

1. Products will be submitted by manufacturers in two shipments. One shipment of screen reclamation products, in bucket containers with manufacturer labels, will be sent to SPTF/SPAI, along with a standard OSHA MSDS; the quantity shipped should be sufficient to clean 3 screens of 10 ft^2 each. The manufacturer will also ship to SPAI a quantity of product necessary to reclaim 50 screens at the volunteer printing facility. SPAI will determine the quantity required for each site and notify the manufacturer prior to shipment.

2. SPTF will determine the effectiveness of all of the products submitted. This will include evaluating the standard manufacturer instructions for each product and ensuring that the application technique specified for that product will enable the product to work effectively. Any instructions for an individual product pertaining to dilution or mixing will be followed. If the application technique specified for a particular product is determined to limit the effectiveness of the product or in any other way negatively affect performance, a second application technique will be chosen and tested.

3. The effectiveness of each product system will be tested with up to three different ink types (solvent-based, UV-cured, and water-based), depending on the recommendations of the manufacturer. The specific methodology for the SPTF testing is detailed in a separate document (see Appendix G). **Only products deemed effective by SPTF will be used in the field demonstration portion of the project.**

4. The selection of printers will take into account the type of inks primarily used and any specialized application equipment. SPAI will match printers with appropriate screen reclamation products. The in-field demonstrations will only include screens on which solvent-based or UV inks have been used. However, if screens on which water-based inks have been used are reclaimed with the product system, the data will be documented.

5. After SPTF has completed the initial screening of the effectiveness of products, SPAI will ship the screen reclamation products to the screen printers participating in the field demonstrations. Products will be packaged in generic containers (no screen product manufacturer markings). The printer will receive the masked product that has a masked OSHA MSDS and a generic label. For all other aspects of the demonstration project, products will be identified only by a letter code.

B. Documentation of Standard Work Practices at Facility

1. The observer will visit the facility and explain the project thoroughly to both the facility point-of-contact, and employees involved in printing and screen reclamation. Prior to the observer's visit, the facility will have received a Facility Background Questionnaire. When on-site, the observer will verify that this questionnaire has been accurately completed. Information categories on the questionnaire include: 1) general facility operations (types of products, number of employees), 2) screen reclamation operations (equipment used, number of screens reclaimed), 3) current reclamation products (application procedures, trade names), 4) storage and disposal practices.

2. The observer will verify the questionnaire and document any other relevant information on the **general facility operations**. Recorded information will include the types of products printed, the printing substrates, the typical run length, and the water, sewer, and electric rates for the facility.

3. The observer will verify the questionnaire and document any other relevant information on the **screen reclamation operations**. The observer will document the size and general specifics of the screen reclamation area(s), including the type of ventilation. The observer will also briefly describe the experience of the employee(s) participating in the test, including past experiences with testing of screen reclamation products, and document any potential biases.

4. The observer will verify the questionnaire and document any other relevant information on the facility's **current reclamation products**. The observer will record the trade name and purchase price of the current screen reclamation products. The observer will document the current work practices by observing screen reclamation utilizing the present method and products used by the facility. The specifics of the screen to be cleaned, such as threads per inch, ink type, color of ink, emulsion type, age, size, tension level and printing history (including estimated time between the end of the press run and reclamation), will be recorded. The physical condition of the screen (small rips, etc.) will be documented before and after the reclamation. The observer will note any pre-application dilution of the product. The observer will measure the quantity of each product applied to the screen and record the time required for each cleaning step, and the overall cleaning of the screen, from application of the ink remover product to the final water wash.

5. The observer will verify the questionnaire and document any other relevant information on the facility's **storage and disposal practices**. The observer will note how the products are stored in bulk and in the screen reclamation area. The current waste and rag disposal practices and costs will be documented by the observer.

C. Phase I: Initial Demonstration and Evaluation at the Printing Facility

1. The employee involved in the performance demonstration will prepare to clean one screen using the masked products supplied for the ink removal, emulsion removal and haze removal steps. The employee will use the application technique designated by SPTF for each product. Prior to the reclamation process, the observer will document any pre-application dilution of the products that is necessary. The observer will note all characteristics of the screen as outlined in B.4.

2. The employee will begin screen reclamation. The observer will record the quantity of each product that is applied to the screen. The observer will record all actions taken by the employee in reclaiming the screen to ensure adherence to any specific instructions. The observer will time the entire process, from the application of the ink remover to the final water wash.

3. The observer will record the effectiveness of the product system in reclaiming the screen, based on visible appearance and the judgment of the printer and the screen cleaning employee. The observer will ask if the screen can be used again for printing and if there are any printing limitations, such as whether it can be used to print a reverse. After the screen is used again for printing, any problems with the screen, such as ghost images or damaged mesh, will be documented by the printer.

4. A second and third screen will then be cleaned using the same method. The observer will follow the process outlined in steps 1 - 3. The purpose of cleaning three screens is to ensure that the screen cleaning employee is familiar with the cleaning method and products, before beginning longer-term testing.

D. Phase II: Further Demonstration of System Effectiveness at the Printing Facility

1. After completion of the above demonstration, the screen reclamation performance demonstration will continue to be performed by the facility through the next thirty days. The masked products supplied by the manufacturer will be used to reclaim these screens. The observer will not be present during this phase of testing. The employee responsible for screen reclamation will record the characteristics of each screen cleaned (see B.4.), the volume of product used for each step in the process, and the effectiveness of the manufacturer system in reclaiming the screen (taking into account future printing performance of each screen). To simplify this process, a short evaluation sheet will be used.

2. During the thirty day demonstration period, the observer will interview the facility contact every week over the telephone to document facts or perceptions concerning the reclamation process that could be helpful in determining the effectiveness of the products used. The observer will determine if there has been any deviation from the initial reclamation procedures. If there has been a deviation, the observer shall record the reasons for the deviation. A work sheet will be developed that will guide the observer through the questions they should ask. The observer will document each conversation on the work sheet, which will subsequently become the telephone log for the facility.

3. If at any time during the long-term phase of the demonstration there is a problem, the screen reclamation employee or facility point of contact will document the specific problem and call SPTF for guidance. Any corrective action will be documented by both the industry specialist and the facility employee.

E. Trouble-shooting

1. If problems arise during the field demonstration of the screen reclamation methods and products, the following procedures will be followed. If the observer is present, the problem will be documented and the observer will call SPTF/SPAI for guidance. If the observer is not present, the facility employee will document the problem and contact SPTF/SPAI.

2. SPTF will first review the procedures used by the facility employee to ensure they are in compliance with the instructions provided with the product. If the procedures are correct, then SPTF will contact the manufacturer for assistance. SPTF will relay and filter the recommendation of the manufacturer to the printer. SPTF/SPAI will ensure the confidentiality of the products is maintained during this period. The identity of the product in the field will remain masked. The observer will document all actions taken.

3. If the recommendations provided by SPTF/SPAI are unsuccessful, the facility employee can attempt to solve the problem. The observer will document the actions taken by the employee responsible for screen reclamation and the success or failure of the actions.

4. If a medical emergency arises, CHEMTREC, the emergency response center of the Chemical Manufacturers Association, has volunteered to respond to emergency phone calls to the manufacturer by identifying masked products with chemical components and providing medical information. The phone number for CHEMTREC will be the emergency phone number listed on the MSDS.

APPENDIX G: Methodology for SPTF Performance Demonstrations

A. Purpose of Testing

Performance data will be collected for each product system in a laboratory setting at the Screen Printing Technical Foundation (SPTF) and also in production runs at 23 volunteer facilities. The testing methodology for the both phases of the demonstrations was developed by consensus with the involvement of EPA, product manufacturers, and screen printers. The protocol was designed to allow the evaluation of the maximum number of product systems given the resources available to the project.

The intent of the SPTF evaluations is to assure that the product systems sent to printers would provide an acceptable level of performance. Screening at SPTF will also provide another set of observations to compare with in-facility demonstration results. All evaluations will be conducted under consistent screen conditions (e.g., tension, mesh type, emulsion type, thread count, image) and each product system will be tested on three imaged screens; one with solvent-based ink, one with UV-cured ink and one with water-based ink.

B. Testing Methodology

Evaluate each product system as follows:

1. Prepare three screens for printing according to the parameters listed in section C.
2. Place a sufficient quantity of the solvent-based ink in the stenciled screen and thoroughly work into the screen with a squeegee. Card out extra ink and allow the screen to sit for approximately 15 minutes. Remove the ink from the screen following the instructions provided to SPTF by the manufacturer. Wipe or wash off the ink (depending on instructions) until it appears that no more ink is coming off on the cloth or in the rinse. Use only enough product to accomplish ink removal to this degree. Record the application procedure, the time it takes to complete the ink removal (time using a digital stop watch), the amount of product used (measure to the nearest 0.5 ounce), the temperature, humidity, product dilution ratio, number of wipes used, ease of use, and comment on the product performance.

3. Repeat step 2 on the second screen using UV-cured ink and on the third screen using water-based ink.

4. Allow each screen to sit for approximately 8 hours to simulate a shop situation. Record the time delay for each screen. Apply the emulsion remover to the screen according to the manufacturers instructions. Record the application procedure, the time it takes to complete the emulsion removal

(time using a digital stop watch), the amount of product used (measure to the nearest 0.5 ounce), product dilution ratio, number of wipes used, and ease of use. Also document if the stencil dissolved easily or slowly, an evaluation of how much scrubbing was needed, if any emulsion was still present, and if any ink haze or stencil stain remained on the mesh. If an initial attempt to remove all the stencil fails, record the screen condition and apply the product again.

5. Apply the haze remover product according to the instructions supplied by the manufacturer. Record the application procedure, the time it takes to complete the haze removal (time using a digital stop watch), the amount of product used (measure to the nearest 0.5 ounce), product dilution ratio, number of wipes used, and ease of use. Also report if any ink haze or stencil stain is present on the mesh. If an initial attempt to remove the haze fails, document the screen condition, and apply the product to the screen again.

6. Based on the testing method described above, SPTF will determine the effectiveness of all of the products submitted. This will include evaluating the manufacturer's application instructions for each product and ensuring that the application technique specified for that product will enable the product to work effectively. If the application technique specified for a particular product is determined to limit the effectiveness of the product or in any other way negatively affect performance, a second application technique will be chosen and tested. **Only products deemed effective by SPTF will be used in the field demonstration portion of the project.**

C. Testing Parameters - Alternative Chemicals

For each ink type tested (solvent-based, UV-cured, and water-based), use the following screen parameters:

Mesh Count per Inch/Thread Diameter:
390/34 LE for UV ink
260/40 LE for solvent- and water-based ink

Supplier/Manufacturer: Tetko/Swiss Silk of Switzerland

Brand Name of Fabric: PeCap LE (Low Elongation)

Mesh Opening: 26 microns

Fabric Thickness: 60 microns

Twill or Plain Weave: Twill Weave

Suggested Tension: 26 N/cm for UV ink
20 N/cm for solvent- and water-based ink

Frame Type: Aluminum

Frame Size: 18" × 20" Outside Dimensions

Tensioning System: Tetko SST Pneumatic Clamp System

Adhesive: KIWO Kiwobond 1000 HMT

Tensioning Procedure:

1. Bring screen directly up to tension using predetermined pressure settings on pneumatic gauges.
2. Let screen set 5 minutes.
3. Check tension, and retension if necessary.
4. Adhere with frame adhesive.
5. Check final tension and record.

Stencil Brand and Type: KIWO Poly Plus SRX dual cure direct emulsion

Scoop Coater Brand and Edge: Tetko Pro-EM round edged coater 12" length

Coating Method: 2 coats on print side, 3 coats on squeegee side, wet on wet.

Image Description: A 10" × 8" pattern of ½" checkers and a ByChrome halftone exposure image.

Exposure System Description: Olec 5KW Metal Halide lamp with 36" distance and light integrator.

Wipe Type: Molnlycke brand P-Tork made from rayon and pure cellulose.

<u>**Ink Types**</u>
Solvent-based Ink: Naz-Dar 9700 Series All Purpose Ink 9724 Black
UV Ink: Nor-Cote CD 1019 Opaque Black
Water-based Ink: TW Graphics WB-5018 Black

Testing Parameters - Sodium Bicarbonate Alternative Technology

During the sodium bicarbonate test, the following parameters were used:

Sodium Bicarbonate:	75 micron particle size Delivered at 1 - 1.5 pounds/minute Sodium Bicarbonate delivered at 5 - 30 psi Water delivered at 200 - 250 psi
Screen:	Polyester mesh mounted on wood frames Dual-cure emulsion 13" x 23" outside diameter
Inks:	Same inks as were used for the alternative chemical systems testing
Ink application:	Each type of ink was applied to one screen, carded off, and the screen was allowed to dry for 18 hours before starting the cleaning test.

APPENDIX H:

Participating Manufacturers

The participation of the following screen printing manufacturers was critical to the success of the performance demonstration. These manufacturers can be contacted through the information given below:

Amerchem
165 W. Mittel Drive
Wood Dale, IL 60191
Contact: J.P. Godinez
708-616-8600

Autotype Americas
2050 Hammond Drive
Schaumberg, IL 60173-3810
Contact: Neil Bolding
708-303-5900

Ciot International Services
48 Marlin Drive
Whippany, NJ 07981-1279
Contact: George Ciottone
201-503-1922

Franmar Chemical Associates
P.O. Box 483
Normal, IL 61761
Contact: Frank Sliney
309-452-7526

Hydro Engineering, Inc.
865 West 2600 South
Salt Lake City, UT 84119
Contact: Bob Roberts
801-247-8424

Image Technology, Inc.
1170 North Armando St.
Anaheim, CA 92806
Contact: Harry Emtiaz
714-632-5292

KIWO
P.O. Box 1009
Seabrook, TX 77586
Contact: Clark King
1-800-KIWO-USA

Nichols and Associates, Inc.
111575 Rupp Drive
Burnsville, MN 55337
Contact: Oliver Nichols
612-895-1766

Ruemelin Manufacturing
3860 N. Palmer St.
Milwaukee, WI 53212
Contact: Charlie Ruemelin
414-962-6500

APPENDIX I:

VOLUNTEER FACILITY PROFILES AND PERFORMANCE DETAILS

PRODUCT SYSTEM ALPHA

Facility Profiles

The operating conditions for each facility that volunteered to reclaim their screens using Product System Alpha for one month are described below. This information is provided as a basis of comparison to review the performance results of Product System Alpha at each of these three facilities.

Profile of Facility 8

Facility 8 prints labels, nameplates, and graphic overlays, primarily on plastics, but they also do some printing on paper and metals. Their typical run length is 100 sheets, and approximately 75% of their orders are repeat orders. Of the 40 - 50 employees at this facility, approximately 3 are involved in screen reclamation. All printing is done with solvent-based inks; both vinyl and epoxy inks are used. All screens used in the Performance Demonstrations were made of a monoester mesh that was treated with a roughening paste and a degreaser when each screen was initially stretched. Mesh count during the demonstration period ranged from 195 - 330 threads/inch and an indirect stencil was used for all screens. The average screen size used at this facility is 24.5 inches x 31.75 inches (778 in^2) and 10 - 15 screens are reclaimed daily.

Currently, Facility 8 uses an ink remover that is a solvent blend of 50% toluene and 50% methyl ethyl ketone, as well as a proprietary blend of propylene glycol ethers (<30%), Stoddard Solvent (a petroleum distillate) (<5%), and d-limonene (<20%). As an emulsion remover, they use a formulation consisting primarily of sodium periodate. Haze remover is only applied to approximately 25% of the screens and information on the chemical formulation of their haze remover is not currently available. Standard application procedures at this facility are comparable to the procedures recommended for the alternative products.

Profile of Facility 13

Facility 13 prints store displays, decals, and outdoor signs. Their products are printed on plastics, paper, and metal. A typical run length is 500 - 1000 sheets and approximately 25% of their orders are repeat orders. There are about 70 employees at this facility and 1 - 3 employees are responsible for screen reclamation. The facility uses both UV ink and solvent-based ink. During the Performance Demonstrations they used a direct photo stencil and the screen mesh was an abraded polyester. Mesh counts ranged from 155 -

390 threads/inch. The screen size typically used in this facility is 49 inches x 41 inches, and approximately 20 screens are reclaimed daily.

Profile of Facility 14

Facility 14 prints three-dimensional panels, pressure-sensitive labels, and specialty items for advertising. Primarily, they print on plastics and metals, but they also do some printing on paper. A typical run is 100 - 300 sheets and approximately 85% of their orders are repeat orders. Of the approximately 12 employees at this facility, 3 are involved in screen reclamation activities. Several different types of ink are commonly used at Facility 14, including thermal setting, vinyls, and UV-cured, and small amounts of lacquers, enamels, and epoxies. All screens used in the Performance Demonstrations were made of a monofilament polyester and a direct photo stencil emulsion was applied. Mesh count during the demonstration period ranged from 305 - 390 threads/inch. The average screen size used at this facility is 12 ft^2 and approximately 12 screens are reclaimed daily.

For ink removal, Facility 14 uses either a product consisting of 99% tripropylene glycol methyl ether, or a proprietary solvent blend sold by a manufacturer not participating in the performance demonstration. MSDS information on the latter product states it contains no hazardous substances, is non-flammable, has no SARA reportable chemicals, and meets California's South Coast Air Quality Management District requirements. Their emulsion remover is a formulation consisting primarily of sodium periodate. For haze removal, they use either an aqueous blend which consists of potassium hydroxide (27%) and tetrahydrofurfuryl alcohol (11%), or an aqueous blend that contains sodium hydroxide (5%) and tetrahydrofurfuryl alcohol (17%). The application procedures the facility uses when applying their standard products are very similar to the methods used to apply the alternative products, however, haze remover is only applied to approximately 6% of the screens when using the standard product.

<u>Product System Alpha Performance Details from Each Facility</u>

Performance Details from Facility 8

Over the four week demonstration period, this facility reclaimed 48 screens with the Product System Alpha. The screen printing manager reclaimed the screens himself during the demonstration period. He was willing to experiment with different application techniques to improve the performance of the alternative products.

The printer thought the ink remover performance was satisfactory, but results were inconsistent and the product required extra scrubbing effort to achieve acceptable results. He noted that the ink remover performance was unacceptable on epoxy inks, even with the extra effort. One specific observation was that the ink remover did not stay wet on the screen which made wiping more difficult. Performance improved, however, when he sprayed the product both on the rag and on the screen. After using the ink remover, the printer evaluated each screen and reported that the ink was removed effectively on 62% of the screens.

Typically, this facility uses hot water to start the breakdown of their emulsion. When following the manufacturer's application instructions for the Alpha emulsion remover, which does not require hot water, the printer found the emulsion came off in "strings," instead of dissolving. The stringy, solid mass clogged the drain. To solve this problem, the printer rinsed the screen with hot water before applying the emulsion remover. This additional step took an extra 3 - 5 minutes, but the emulsion remover performance improved.

The haze remover did not sufficiently remove the haze on approximately 20% of the screens. The printer wiped these screens with lacquer thinner (which easily removed the haze) before reusing the screen. The observer confirmed that this supplementary wipe down was necessary and noted that the white rag with lacquer thinner on it turned black as the dark haze was removed from the screen. Overall, the printer felt the alternative haze remover performance was not acceptable.

Data from the printer's product evaluation forms was analyzed to determine if there were any correlations between variations in the product performance and changes in the demonstration conditions (e.g., ink type, emulsion type, screen condition). The printer was asked to evaluate the screen after using each product (ink remover, emulsion remover, and haze remover). In addition, the printer recorded the amount of ink remaining on the screen at the start of reclamation. In reviewing this data, it was found that for screens where the initial ink remaining on the screen was high (i.e., it was not carded off well), there was an ink stain remaining on the screen after emulsion removal (for 100% of the screens in the demonstration). When the initial ink remaining on the screen was recorded as "low", an ink stain remained after emulsion removal for only 33% of the screens. This could indicate that if the screen is effectively carded before ink removal (as the manufacturer recommends), the product performance may improve significantly. Overall, 76% of the screens had an ink stain or stencil stain after using the emulsion remover. After applying the haze remover, 20% of the screens could not be reused because of the remaining haze.

During the four week demonstration, this facility did not notice any change in screen failure rate or any deterioration of the screen mesh. The printer had no problems with print image quality while using Product System Alpha, however, he felt he avoided potential print quality problems by cleaning the screens again with his own ink remover before reusing them.

Performance Details from Facility 13

Overall, this facility was not satisfied with the performance of System Alpha. The alternative products required more time and effort than their standard products and were not as effective in cleaning the screens as their standard products. Because of the extra time required, the facility could not reclaim screens fast enough to keep up with their need to reuse the screens. The screen reclaimer also did not like the strong smells associated with the alternative products. For these reasons, the printing manager made the decision to discontinue participation in the demonstrations after two weeks. More experimenting with application methods could have lead to improved performance, but this facility did not seem willing to try. The facility contact also mentioned that the reclamation employee was not reliable and that he did not feel confident in the screen reclamation results that were provided. In analyzing the limited data from this facility, the performance of the alternative products did not seem to be affected by ink type, ink color, mesh type, or other demonstration conditions.

The ink remover did not perform as well as their usual product. It removed ink less effectively than was expected and involved more applications and rinsing (which meant more time) to get the ink out of the mesh. The only application changes attempted were to use more product and effort. The added scrubbing was considered a very negative characteristic of the ink remover.

Even at full strength the emulsion remover required more scrubbing and time to remove the emulsion from the screens than their usual product. The alternative emulsion remover did remove the stencil, however, because of the extra time required, the facility discontinued use of the emulsion remover after the first week of demonstrations.

The haze remover did not reduce stains in the mesh as effectively as the facility's usual haze remover. Almost every time the haze remover was used, the facility had to follow with their usual haze remover to get the screen clean enough for reuse. When using their standard product system, this facility needed to use a haze remover for only about 30 percent of their screens. Facility 13 did not experiment with application methods other than extra scrubbing and they stopped using the haze remover after the first week of demonstrations.

No changes were noted in the screens used with the alternative products. Longer-term use of the alternative products may have damaged the screens or reduced screen life because of the excessive scrubbing that was needed with Product System Alpha.

Performance Details from Facility 14

Performance of System Alpha was average at Facility 14. The results are complicated by the fact that three different people were involved in the demonstrations and the two original screen reclamation employees were terminated after about three weeks into the demonstration period. The initial data quality seemed good, but a lot of information was missing from the forms that were submitted from the last week(s) of employment of the terminated employees. The new screen reclaimer may not have followed the same procedures when using the alternative products.

The ink remover worked fairly well, but sometimes had to be reapplied for the screens to be thoroughly cleaned. The product worked particularly well with vinyl inks. The ink remover's performance was improved by applying the ink remover immediately after a print run and letting it sit on the screen for up to a day before it was pressure rinsed off. The manufacturer's directions do not give any recommendations of the soaking time for the ink remover.

The emulsion remover was reported to have worked well at this facility and it worked faster than their usual product. In one case, however, the emulsion remover left a slight green tint in the screens, but this was removed by their usual haze remover.

The initial screen reclaimers felt that the haze remover had average performance, but the final reclaimer felt that it left more of a haze in the mesh than she expected. This later reclaimer only used the product on a few screens and may not have applied the ink remover immediately after the press run which the original employees were doing to improve the performance of the ink remover. This may explain why the new employee thought that more haze than usual was left on the screens. The alternative haze remover and the standard haze remover used at this facility are almost identical chemically. Also, the print quality was very rarely documented by this facility, although it may be safe to assume that problems with print quality would have been reported, if obvious.

The analysis of the data from this facility did not show any correlation between the performance of the alternative products and any variations in ink type, ink color, mesh type, or other demonstration conditions. No side effects on the screens or changes in the screen failure rates were noted during the demonstrations.

ALTERNATIVE PRODUCT BETA

Facility Profile

The operating conditions for the facility that volunteered to reclaim their screens using Product Beta for one month are described below. This information is provided as a basis of comparison to review the performance results of Product System Beta at the facility.

Profile for Facility 12

Facility 12 prints graphic overlays, labels, and flexible membrane switches on plastics, paper, and metals. Their typical run length is one hour, and approximately 70% of their orders are repeat orders. There are about 10 employees involved in screen printing at this location, and approximately 4 are involved in screen reclamation. Solvent-based vinyl and polyester inks used at this facility. Screens with mesh counts of 195 - 390 threads/inch and capillary film emulsions were used during the demonstrations. The average screen size at this facility is 9 ft^2 and 10 - 15 screens are reclaimed daily.

This facility uses a solvent blend ink remover containing 50% toluene and 50% acetone. Their emulsion remover consists primarily of sodium periodate. For haze removal, they use a proprietary solvent blend which includes sodium hydroxide and cyclohexanone. The method Facility 12 typically uses for ink removal is similar to the method recommended for the alternative ink remover.

PRODUCT SYSTEM CHI

Facility Profiles

The operating conditions for both facilities that volunteered to reclaim their screens using Product System Chi for one month are described below. This information is provided as a basis of comparison to review the performance results of Product System Chi at each of the two facilities.

Profile of Facility 3

Facility 3 prints decals and vacuum formed sheets on plastics and paper. A typical run is 250 sheets, and 71% of their orders are repeat orders. Of the approximately 40 employees at this facility, 1 - 3 are involved in screen reclamation. All printing is done with solvent-based inks. Screens used in the Performance Demonstrations were polyester or monoester/polyester with a mesh count of 180 - 370 threads/inch. The facility used a dual cure emulsion. The average screen size at this facility is 15 ft^2 and approximately 15 screens are reclaimed daily.

As their standard ink remover, Facility 3 uses a proprietary solvent blend, which consists of n-butyl acetate (81%) and toluene (19%). For emulsion removal, they use a formulation consisting of 100% sodium periodate. They use two different haze removal products at this facility. One product is a proprietary solvent blend which contains at least sodium hydroxide and cyclohexanone. Their other haze removal product, sold by a manufacturer who is not participating in the performance demonstration, contains no carcinogens, no ingredients with TLVs or PELs, and no petroleum derivatives, according to the MSDS. Application procedures for the alternative products were the same as the facility's standard procedures, except in the case of the ink remover. In their standard practice they rinse the ink off with a pressure wash, and when using the alternative method, the ink is wiped off with a cloth.

Profile of Facility 21

Facility 21 prints decals for glass and ceramics. Their typical run length is 1000 sheets and approximately 50% of their orders are repeat orders. There are approximately 15 -20 employees at this facility, and 1 - 3 people are responsible for screen reclamation. During the Performance Demonstration, this facility used solvent-based inks, a capillary film emulsion, and screens with mesh counts that ranged from 60 - 390 threads/inch. Their average screen size is 3 feet x 3 feet and 20 - 25 screens are reclaimed daily.

The standard ink remover at Facility 21 is a proprietary product, sold by a manufacturer not participating in the performance demonstration, that contains no carcinogens, no ingredients with TLVs or PELs, and no petroleum derivatives, according to the MSDS. Their emulsion remover contains primarily sodium periodate. Their standard haze remover is a proprietary solvent blend which includes sodium hydroxide and cyclohexanone. The application procedure recommended for the alternative products is very similar to the application method the facility uses for their standard products. Typically, their standard haze remover is only used on 1% of the screens reclaimed. The need for the alternative haze remover was similar; it was required on one screen out of the 48 screens reclaimed during demonstrations.

Product System Chi Performance Details from Each Facility

Performance Details from Facility 3

Throughout the performance demonstration period, the facility contact was asked about the performance of the components of Product System Chi. He was generally pleased with the performance of the ink remover and emulsion remover, although the ink remover took longer to solubilize the inks than their standard product in some cases. when used as a haze remover, the ink remover usually did not remove the ghost image from the screen. Overall, the facility contact remarked that he did not think that System Chi would be a viable long-term alternative reclaiming system for his plant.

The ink remover worked acceptably on all screens, although it was somewhat slower to dissolve the inks than the facility's regular ink remover. The printer tried using the product to clean the squeegee and flood bar on the press after printing runs, but found that it was slow to break down the ink and left an oily film. After several cycles of printing and reclaiming with the demonstration screens, a noticeable ink haze began to build up in the screens, indicating that the ink remover was not removing all the ink from the mesh. The buildup was not enough to prevent successful printing of regular jobs with the screens, but the facility contact felt that the performance of the screens on a transparent ink image or a flood coat would be unacceptable. There were some variations in the time it took to remove the ink, ranging from 2 to 12 minutes. However, the recorded data does not show any correlation between the ink remover time and any of the variable screen conditions, such as ink color or number of impressions.

The emulsion remover worked well, with no notable variations in performance among the screens used for the demonstration period. The facility contact did not think the product was chemically different from what he had been using previously.

This system did not include a haze remover; instead the manufacturer recommended applying the ink remover again to remove any remaining haze. At Facility 3, the ink remover did not satisfactorily remove the haze. Ghost images continued to build on the screens throughout the demonstration period. The facility normally uses two haze remover products. One haze remover is a milder chemical, which leaves a small amount of ink haze in the screens. This product is used by itself on a regular basis until ghost images in the screen become unacceptable. The other haze remover, which is a stronger chemical, is then used to de-haze the screen to a baseline clean state, after which the screen reclaimer returns to the milder chemical for as many reclaimings as possible. The facility contact remarked that the performance of the alternative haze remover is similar to their "milder" regular haze remover, except that the ink haze built up faster using the alternative product.

Product System Chi did not appear to cause screen failure, or have any noticeable permanent effects on the screens or frames. The three squirt bottles shipped with the products started leaking around the triggers during the first week of the demonstration, and had to be replaced. It is not known if this is an effect of the products or not.

Performance Details from Facility 21

This facility was generally pleased with the performance of System Chi. Currently, the facility uses an automatic screen washer, which cleans the screens in a closed system that recycles the solvent. This was a very organized facility and the quality of the data received was probably quite high. They thoroughly documented the demonstrations and only one screen reclaimer was involved in the demonstrations. The production manager was responsible for monitoring the future print quality on screens reclaimed with the alternative products. He paid very careful attention to screen conditions and would have noticed any deleterious effects of the alternative products. No changes in the screen mesh or print quality were noted during the demonstrations.

The ink remover worked well, however it was not as efficient as their standard product. The facility particularly liked the ink remover's performance with metallic inks. When used on screens with cover (flux) coats or with other clear ink coats, the ink remover did not work well, although the facility has similar problems with their current ink remover. Added scrubbing was needed to remove ink from very coarse (low mesh count) screens. Ink color and number of impressions did not seem to affect ink remover performance.

The emulsion remover worked much better ("excellent") than the product they had been using. Although it worked very well on both emulsion types, the emulsion remover required a little more effort to remove capillary film emulsion than direct emulsion.

For Product System Chi, a second application of the ink remover was used in place of a haze remover as needed. At this facility, a haze remover was needed on only one screen. On that screen, a ghost image remained in the mesh after using the ink remover one time. After reapplying the ink remover two more times, the image was lightened enough to reuse the screen. Normally, this facility does not use a haze remover.

PRODUCT SYSTEM DELTA

Facility Profiles

The operating conditions for each facility that volunteered to reclaim their screens using Product System Delta for one month are described below. This information is provided as a basis of comparison to review the performance results of alternative product system at each of these two facilities.

Profile of Facility 10

Facility 10 prints store displays, primarily on paper, but they also print on plastics, metal, ceramic, glass, and other materials. Their typical run length is 200 - 500 impressions and less than 5% of their orders are repeat orders. Of the approximately 25 employees at this facility, 1 - 3 are involved in screen reclamation activities. The screens used in the Performance Demonstrations were twill mesh with mesh counts of 305 - 390 threads/inch and a direct photo stencil was applied. The average screen size at this facility is 70 inches x 100 inches and 5 - 10 screens are reclaimed daily.

Facility 10 uses a proprietary blend ink remover consisting of at least propylene glycol ethers and dimethyl adipate. For emulsion removal, they use a proprietary aqueous mixture which contains periodate salt (<10%). Their haze remover is a proprietary aqueous mixture which contains sodium hydroxide (<15%) and is only required on 2 - 5% of the screens reclaimed. The application method recommended by the alternative product system manufacturer is the same as the procedure used for this facility's standard product system with the exception of the ink remover. The alternative ink remover is washed off with a pressure wash and the standard ink removed is wiped off with rags.

Profile of Facility 11

Facility 11 prints fleet graphics and pressure sensitive decals. Typically, they print about 100 units per run and 50% of their orders are repeat orders. There are approximately 35 employees at this facility, and 1 - 3 people are involved in screen reclamation activities. During the Performance Demonstrations, this facility used UV-cured inks and a direct photo stencil. Screens with a monofilament twill weave and a mesh count of 390 threads/inch were used. The average screen frame size used in this facility is 68 inches x 88 inches and approximately 5 screens are reclaimed per day.

Facility 11 uses a standard ink remover that is a proprietary product, sold by a manufacturer not participating in this project. According to the MSDS, this product contains no carcinogens, no ingredients with TLVs or PELs, and no petroleum derivatives. Information on the emulsion remover used at Facility 11 was not available. Their haze remover is a proprietary aqueous mixture that contains sodium hydroxide (<15%), but it is used on only 1 - 3% of the screens reclaimed. The application procedures for the alternative product system are very similar to this facility's standard application methods.

Product System Delta Performance Details from Each Facility

Performance Details from Facility 10

System Delta had average success at this facility. The ink remover performance was acceptable and the emulsion remover worked very well. A second application of the ink remover as a haze remover did not remove the haze from the screens, therefore the facility used their standard haze remover when needed. After three weeks, the print manager decided they did not want to continue their participation in the performance demonstrations because their standard ink remover and haze remover worked better than the alternative products.

The ink remover's effectiveness was considered average at this facility. Prior to the performance demonstrations, the facility was using an ink remover that had a chemical composition very similar to that of the ink remover supplied in Product System Delta. This facility cards off excess ink and also wipes the screen with a rag so there is very little ink left on the screen when the ink remover product is applied. The reclaimers did not like using this product because of its strong smell and many of the employees felt that the ink remover gave them headaches. Facility 10 did not use a pressure wash to remove the ink, as recommended by the manufacturer. Instead, they wiped off the dissolved ink with reusable rags.

The emulsion remover was very effective when diluted one part emulsion remover to one part water (the manufacturer recommends diluting with 4 - 5 parts water). At this dilution level, the reclaimers were very pleased with its performance and wanted to continue using the product. This facility also liked the emulsion remover's lack of odor. When they first started using this emulsion remover, they diluted it in 4 parts water, as recommended. They found it did not work as well as their usual emulsion remover, so they tried diluting it in two parts water, and found it worked best when one part emulsion remover was diluted in one part water.

The facility infrequently documented the performance of the ink remover as a haze remover when applied a second time. After only a few screens, they felt that their usual haze remover worked much more effectively. On most of the screens, no haze remover was needed, however, when it was required, Facility 10 used their standard haze remover after using the alternative ink remover and emulsion remover.

Facility 10 did not notice that the alternative products performed differently with screen conditions. The data did not show any correlations between screen conditions (e.g., ink color, ink drying time) and indicators of performance (e.g., time to clean, quantity of product used). The printer felt that screens that sat around for days before reclamation were more difficult to clean than screens cleaned immediately after the print run ended.

No changes were noticed in screen wear or in screen failure rates. Print image quality was good, however, since they were using their own haze remover, it is difficult to determine if there would have been any changes to the print image quality as a result of using only the alternative product system.

Performance Details from Facility 11

Overall this facility felt that System Delta worked well. The printing manager felt that if the alternative products are actually safer for his workers or for the environment, then he would like to use this product system at his facility. The application procedures for the alternative products closely resembled their usual reclamation procedures and this similarity may have made Facility 11 more receptive to using System Delta.

The ink remover effectively removed the ink from the screens in all instances. A UV-cured ink system was used with all screens in the demonstrations. The printer commented that the ink remover was "less effective" when the ink dried on the screen for a long time. The data from this facility shows that screens where the reclaimer took 5 minutes or less to remove the ink had dried an average of 2.7 hours prior to ink removal. Screens where the ink removal step took longer than 5 minutes had dried an average of 21.6 hours. By applying the ink remover immediately after the press run, as recommended by the manufacturer, it appears time spent on ink removal could possibly be reduced. Facility 11 followed the manufacturers instructions and used a pressure wash to remove the ink from the screen. Before the ink removal step, most of the ink was carded off the screen.

The emulsion remover worked very well for this facility at a variety of concentrations. The initial reclamations were performed without diluting the emulsion remover and performance was very good. After trying several different dilution ratios, they found a mix of one part product to three parts water worked very well at this facility. After applying the ink remover and emulsion remover, the screens were clean enough that a haze removing step was unnecessary. Even without a haze remover step during the reclamation process, the print quality was excellent. When using their usual products, this facility attempts to minimize their use of haze remover; they only uses haze remover to clean a screen when there is a haze that has built up over time or when much adhesive remains in the screen.

The same screen reclaimer performed all of the demonstrations and evaluated the printing performance of the reclaimed screens. However, the reclaimer was moved to the position of printer during the demonstrations period. Undoubtedly, this change reduced the number of screens that were reclaimed with the alternative product and the forms were also lacking in details. Since he was pleased with the alternative product performance, he did not take the time to record many specific details. Overall the use of System Delta did not produce any deleterious effects of the screen mesh or subsequent print image quality. The printing supervisor noted that the alternative products may be reducing their screen failure rate.

PRODUCT SYSTEM EPSILON

Facility Profiles

The operating conditions for each facility that volunteered to reclaim their screens using Product System Epsilon for one month are described below. This information is provided as a basis of comparison to review the performance results of alternative product system at each of these two facilities.

Profile of Facility 20

Facility 20 prints banners and point-of-purchase displays on paper, plastic, metals, ceramics, and glass. Their typical run is 20 parts and about 20% of their orders are repeat orders. Of the approximately 10 employees at this facility, 1 - 3 are involved in screen reclamation activities. The facility uses a variety of solvent-based inks including vinyl, enamel, and a multipurpose ink. They use a dual cure emulsion. Screens used in the Performance Demonstrations were polyester (untreated) with a mesh count of 83 -280 threads/inch. The average screen size at this facility is 4 feet x 5 feet and approximately 5 - 10 screens are reclaimed daily.

The standard ink remover product at Facility 20 is an acetone blend. For emulsion removal, they use a proprietary aqueous mixture which includes periodate salt (<10%). Their standard haze remover is a proprietary aqueous mixture with sodium hydroxide (<15%). There are some differences between the application method for the alternative product system and that of their standard system. The alternative ink remover is rubbed into the screen with rags and then pressure washed. For the standard product, the ink is wiped off with rags and there is no wash. When using the alternative haze remover, the facility lets the product set on the screen for one or two minutes, however, with the alternative product, the wait time is 10 - 30 minutes. These differences in application procedure did not seem to affect the opinions of the printers evaluating the products.

Profile of Facility 24

The majority of the products printed by Facility 24 are pressure sensitive mylar labels and polycarbonate Lexan face plates. Run lengths are typically 500 - 1000 impressions, and approximately 50% of their business is for repeat orders. There are 15 - 20 employees involved in production operations at this facility and 2 - 3 are involved in screen reclamation operations. The facility uses both solvent-based inks and UV inks; sometimes on the same screen. They use a direct photo stencil and a monofilament (untreated) polyester mesh. All screens used in the Performance Demonstrations had a mesh count of 355 threads/inch. The average screen size at this facility is 36" x 36" and 3 - 5 screens are reclaimed each week.

Facility 24 uses a proprietary solvent blend ink remover consisting primarily of cyclohexanone, diacetone alcohol and dipropylene glycol methyl ether. Their emulsion remover is a proprietary aqueous mixture with at least sodium periodate. Their standard haze remover is an aqueous blend consisting of sodium hydroxide (5%) and tetrahydrofurfuryl alcohol (<15%). Application procedures for the alternative products were very similar to the methods of application for this facility's standard products.

Product System Epsilon Performance Details from Each Facility

Performance Details from Facility 20

Users of the reclaiming products were asked to evaluate the performance of the components of System Epsilon relative to the facility's regular system. The screen reclaimer thought that the products were generally better than their previously used ones. The operations manager, however, felt that the ink remover did not perform quite as well in cutting some inks as their previously used products. No evaluation sheets were received from Facility 20, although the facility reported that they sent them. Unfortunately, they did not make copies of the sheets before they were mailed. Therefore, all performance information from Facility 20 was received through the observer's on-site documentation and through weekly telephone conversations with the facility. The observer interviewed both the reclamation employee and the operations manager, who was also one of the printers who used the ink remover.

The ink remover worked acceptably in the facility, although some of the printers who used it complained that it acted slowly. Performance was not as good on catalyzed inks as on other solvent-based inks. The catalyzed inks also require more effort to remove with the facility's regular ink remover, but the alternative product did not perform as well as the regular product in this case. The alternative product did eventually remove all the ink from the screens. The operations manager, who also used the product, commented that it was more of an respiratory irritant than their previously used product; he said that the alternative product smelled bad and made him dizzy.

The emulsion remover worked well at this facility. One screen, with an 83 mesh screen that had been used with an aggressive ink system, required at least two applications of emulsion remover to clean. Two applications of emulsion remover are also required when using the facility's standard emulsion remover with this type of screen. The reclaimer felt that either the coarse mesh or the ink system could have made the screen more difficult to clean.

Haze remover performance was acceptable. Again, when reclaiming screens with a mesh count of 83 threads per inch, the haze remover also had to be applied 2 or 3 times.

Overall, the use of Product System Epsilon had no deleterious effects on the screen mesh or on the subsequent print quality image and the printer did not notice any change in screen failure rate over the time period that the alternative products were in use.

Performance Details from Facility 24

This facility felt the ink remover and the emulsion remover worked better than their standard system, and the haze remover performed as well as their own product. Screen printing is a relatively small part of the operations at this facility, and although they used Product System Epsilon on all the screens they reclaimed, the total number of screens over four weeks was 14.

The ink remover consistently removed the both the solvent-based and the UV-cured inks. Although the product performance was good for both ink types, this printer found the UV inks easier to clean than the solvent-based inks. In addition, the facility found the quantity of alternative ink remover used per screen was significantly less than the quantity used of standard product.

The printer felt the emulsion remover was as effective as their standard product, and it dissolved the stencil quickly. Product System Epsilon haze remover performance was evaluated as the same as the facility's standard haze remover. Although the data from this facility indicates that there were several cases where the screen could not be reused for reverse printing or for use with transparent inks, the printer felt that these restrictions were not entirely due to the alternative products. Some of the remaining ink stains may have been on the screen prior to the start of the alternative products demonstrations.

During the four weeks the products were used in this facility, no change in the screen failure, mesh deterioration, or print quality were noted. The observer felt the facility evaluated the alternative product's performance objectively and conscientiously. At the conclusion of the demonstrations, the printer mentioned that he was interested in continuing to use the alternative ink remover and emulsion remover.

PRODUCT SYSTEM GAMMA

Facility Profiles

Profile of Facility 16

Facility 16 prints fleet vehicle markings on vinyl film. Their typical run length is 200 sheets, and approximately 60% of their orders are repeat orders. There are over 50 employees at this location, and 7 - 10 are involved in ink removal and 1 - 3 are involved in screen reclamation. For the performance demonstrations, all inks used were solvent-based on polyester or monoflex screens with capillary film emulsions. Screens mesh counts of 200 - 390 threads/inch were used for the demonstrations. Average screen size at this facility is 12 ft^2 and approximately 20 screens are reclaimed daily.

The standard ink remover at this facility contains at least tripropylene glycol methyl ether. For emulsion removal, they use a proprietary aqueous mixture with at least sodium periodate. This facility uses two different haze removers: a paste which contains 25% sodium hydroxide, and a liquid which contains cyclohexanone (25%), butyl cellosolve acetate (25%), benzyl alcohol (25%), and diacetone alcohol (20%). The application methods for the standard ink remover and haze remover were the same as the procedures for the alternative products. The alternative haze remover, however, required a waiting time one hour longer than the standard product. This change in procedure did not seem to affect the results.

Profile of Facility 25

Facility 25 prints point-of-purchase displays and overlays for appliances and automotive applications. Print runs at this facility average 16 hours and approximately 80% of their orders are repeat orders. During the Performance Demonstration, this facility used solvent-based inks and a direct photo stencil on polyester screens with mesh counts of 175 - 420 threads per inch. The most common screen sizes at Facility 25 are 42 inches x 42 inches and 42 inches x 50 inches. Approximately 25 screens are reclaimed daily.

This facility's standard ink remover is a solvent blend which includes the following chemicals: cyclohexanone (<60%), xylenes (<5%), ethyltoluene (<15%), trimethylbenzenes (<35%), C-10 aromatics (<5%), and cumene (<5%). They also use another solvent blend which contains methyl ethyl ketone (<35%), toluene (<55%), n-butyl acetate (<20%), and heptane (<15%). Their emulsion remover is a proprietary aqueous mixture with at least periodate salt (<10%). For haze removal, this facility uses a proprietary aqueous mixture with at least sodium hydroxide (<15%). Use of the alternative products required some changes from the application procedures typically used by this facility. When using the alternative ink remover, the screen is rinsed to remove the ink, whereas the standard ink remover is wiped off the screen. The standard haze remover requires a one minute wait, and the alternative product required at least a one hour wait, and up to 24 hours. This additional waiting time may have inconvenienced the operators and influenced their opinions of the product performance.

Performance Details from Facility 16

Product System Gamma ink remover and haze remover did not work well and Facility 16 decided not to use these products during the demonstration period. The emulsion remover seemed to work very well; it was evaluated for the entire four-week demonstration period. During the demonstrations, there did not appear to be any change in the screen failure rate, or any noticeable effects on the screen mesh or frames.

The ink remover was only used to clean four screens. The printer sprayed the product on and let it sit for 30 second before wiping. In all cases it took a lot of effort to clean the screens. The ink remover left an oily film and an ink residue in the mesh. The facility decided to discontinue using the alternative ink remover based on these results.

The emulsion remover worked well, with no notable variations in performance among the screens used during the demonstration period. Although the product instructions require waiting 1 - 2 minutes after applying the product before pressure washing, the reclaimer found that the emulsion began to fall off the screen within 30 - 45 seconds after application. Screens were therefore pressure washed sooner than specified, with no noticeable effect on product performance. Facility 16 uses screens encompassing a large range of sizes, including some very large screens used for producing fleet markings for semi-trailers. The amount of emulsion remover used to clean the screens varied accordingly, although the results were consistent.

At this facility, the haze remover did not remove ghost images from the screens. After initial printing using the prescribed procedure, the screen reclaimer left the haze remover on a screen for 48 hours in an attempt to remove the ghost image, with no success. The facility had to use their regular haze remover on the screens in order to be able to reuse them in production. Use of the alternative haze remover was discontinued and the product was not included in the performance demonstration. For both the haze remover and the ink remover, an insufficient number of screens were reclaimed with these products to determine any correlations between demonstration conditions (e.g., number of impressions, ink color) and the product performance.

At Facility 16, one employee applied the ink remover, and a second reclaimed the screens and evaluated the printing quality on subsequent runs. Neither of these employees had direct contact with the observer during the performance demonstration. Three different people served as the facility contact during the course of the study. The confusion of so many different contacts probably prevented the performance demonstration from being managed as closely as it was in other facilities.

Performance Details from Facility 25

Although all three components of System Gamma were used during part of the performance demonstrations, the ink remover and haze remover did not work well enough to be used for the complete four week period. The emulsion remover worked well and was used for the entire demonstration period. During the demonstrations, the printer did not notice any changes in the screen failure rate or any detrimental effects on the screen mesh, or frame.

The ink remover did not work well at Facility 25. It should be noted that the standard ink remover used at this facility is chemically very different from the alternative ink remover supplied as part of Product System Gamma. Adverse chemical interactions may have occurred on some of the older screens due to the differences in the chemicals, and may have affected all phases of the alternative product performance. The employee who used the alternative ink remover tried several different procedures in order to improve the performance such as using presoaked rags to get more ink remover on the screen, waiting 3 - 5 minutes after application before wiping the ink, and laying rags soaked in ink remover over the screen as soon as it came off the press. Although these procedures helped remove the ink from the stencil surface, there was still a large amount of ink left in the screen; enough to completely block the mesh in some cases. The residual ink was not removed by the emulsion and haze removal steps. The facility used the alternative ink remover for a week and a half before they had to stop because of the poor performance. None of the screens cleaned with this alternative product worked well in production, so they all had to be reprocessed with the facility's regular products before acceptable printing quality was achieved. The facility used several different solvent ink systems and, in reviewing the data from the printer's observations, the ink system and the length of the ink drying time seemed to be the most influential variable in determining the level of performance of the alternative products. However, the ink remover performance was not acceptable for any of the ink systems used.

The emulsion remover performed consistently well on all screens and stencils. The reclaimer found that the product acted faster on the stencil if the screen was wetted before applying the emulsion remover.

The haze remover did not work well. The haze remover was allowed to react on the screens as long as 24 hours, without successfully removing the ink haze. The reclaimer continued to use the haze remover after use of the ink remover was suspended, to see if it would perform better if the haze was less severe. She found that the haze remover worked better if the screens were dried before the product was applied. Even so, too much ink haze was left in the screens to be able to successfully reuse them. Ink residue left in the mesh caused ghost images in subsequent jobs, and eventually solubilized in similar ink systems, which caused the inks to become discolored during the printing runs. Facility 25, therefore, discontinued the use of the alternative haze remover after the second week of demonstrations.

At Facility 25, printing quality judgements were made by the printer, along with the other employees involved in the study. The personnel involved seemed to work hard to try to get acceptable results from the products.

PRODUCT SYSTEM MU

Facility Profiles

The operating conditions for each facility that volunteered to reclaim their screens using Product System Mu for one month are described below. This information is provided as a basis of comparison to review the performance results of alternative product system at each of these two facilities.

Profile of Facility 17

Facility 17 prints decals on paper, plastics, metals, ceramics, and glass. Their typical run length is 400 impressions, and approximately 5% of their orders are repeat orders. There are about 5 employees at this location, and 1 - 3 are involved in screen reclamation. Both solvent-based and UV-cured ink systems are used at this facility; primarily UV inks were used during the performance demonstrations. Screens with mesh counts of 280 - 390 threads/inch and direct photo stencils were used for the demonstrations. The average screen size at this facility is 16 ft^2 and approximately 25 screens are reclaimed daily.

The standard ink remover used at Facility 17 is a proprietary blend consisting of at least propylene glycol ethers (<50%). Their emulsion remover is a proprietary aqueous mixture which contains periodate salt (<10%). For haze removal, they use a proprietary aqueous mixture with sodium hydroxide (<15%). This facility did not have to modify their application procedures significantly when switching from their standard products to the alternative product system.

Profile of Facility 22

Facility 22 prints back-lit automotive graphic overlays on plastics. Typically, they print about 500 sheets per run and approximately 90% of their orders are repeat orders. There are approximately 40 employees at this facility, and two people are involved in screen reclamation. During the Performance Demonstration, this facility used solvent-based inks and a direct photo stencil. Polyester screens with mesh counts of 230 - 305 threads per inch were used. The average screen size in this facility is 40 inches x 40 inches and approximately 12 screens are reclaimed daily.

For ink removal, Facility 22 uses a custom solvent blend which consists of ethyl acetate (20% - 27%), methyl ethyl ketone (20%), and xylene (20%). As an emulsion remover, they use a proprietary aqueous mixture with at least sodium periodate. Their standard haze remover is a proprietary blend which consists primarily of tripropylene glycol methyl ether. To use the alternative product system, this facility did not have to change their standard procedures for application of the ink remover or the emulsion remover. The alternative haze remover, however, did require a waiting time of at least one hour (and up to 24 hours), whereas their standard haze remover did not have a wait time. This additional time may have influenced the printer's opinion of the product performance.

Product System Mu Performance Details from Each Facility

Performance Details from Facility 17

Facility 17 thought that Product System Mu cleaned the screens well and the screen reclaimer noted that the fumes associated with the alternative products were not as bad as those produced by the facility's usual products.

The ink remover performed well. Compared to their standard product, the reclaimer noted that when using the alternative product he did not have to scrub the screens as much and did not have to use as much product to get the screens clean. The printer commented that it was more difficult to remove all of the ink from the screen when the previous print run was a long one. However, the data, although limited, do not show a change in the scrubbing time required corresponding to a change in the length of the previous run. Black UV inks were not removed as effectively as other UV ink colors.

The emulsion remover performance was very good on all screens. The haze remover worked well in most cases, except when the haze was unusually dark. This facility normally uses two haze removers: one is a weaker chemical that is used more frequently and the other, stronger chemical, is only used for stubborn stains. The Product System Mu haze remover worked better than the weaker of their two usual haze removal products, but not as well as the stronger chemical. On the one screen they reclaimed that had solvent-based ink on it, the alternative haze remover did not remove the haze and the printer had to use their stronger haze remover to clean the screen. All other screens reclaimed had been used with UV ink, and on these screens, the facility felt that the alternative haze remover performed as well as and more quickly than the weaker of their two haze removers.

Using the alternative products did not substantially change the screen cleaning routine at this facility. The printer did not notice any changes in the screen condition during the time the alternative products were in use. If less scrubbing is associated with the use of the alternative products, then screen abrasion and possibly the screen failure rate could decrease with continued use of the alternative products.

Profile of Facility 22

This facility found the performance of Product System Mu ink remover and haze remover was not acceptable. The printer thought the emulsion remover performance was very good.

The ink remover was applied to the screens immediately after completion of the press runs. Cleaning the screens still took a high level of effort and a long time to accomplish. All screens took at least 20 minutes to clean, and two screens took 60 minutes. Screen cleaning required 10 - 16 ounces of product; because of the large quantity required, the facility ran out of ink remover after cleaning the twentieth screen. Even with this extra effort, and extra product, an ink residue remained on the screens. The ink remover was especially ineffective on ink which built up partially dried on the edge of the screen during long runs. Overall, the facility contact commented that the product did not seem to cut the ink at all. It should be noted that the standard ink remover used by this facility contains strong hydrocarbon solvents and is chemically very different from the alternative ink remover. These chemical differences may have led to an adverse chemical interaction.

The emulsion remover worked well, with no notable variations in performance among the screens used. It required a low level of effort, and consistently removed all the emulsion from the screens. The performance of the haze remover proved to be unacceptable at Facility 22. Ghost images were not removed from the screens and the facility was not able to reuse the screens until they were treated with their standard haze remover. For this reason, use of the alternative haze remover was suspended during the first week of the demonstration.

At Facility 22 the facility contact, who was the product development manager, removed the ink, reclaimed the screens and evaluated the printing quality on subsequent runs. Although these were not tasks he usually performs, it should have ensured consistency of judgement on the product performance evaluations. Product System Mu did not appear to cause screen failure, or have any noticeable effects on the screens or frames.

PRODUCT SYSTEM OMICRON-AE

Facility Profiles

The operating conditions for each facility that volunteered to reclaim their screens using Product System Omicron-AE for one month are described below. This information is provided as a basis of comparison to review the performance results of alternative product system at each of these two facilities.

Profile of Facility 2

Facility 2 prints signs, banners, and store displays on plastics and paper. A typical run is 150 pieces and approximately 40% of their orders are repeat orders. Of the approximately 12 employees at this facility, 5 are involved in screen reclamation. All printing is done with solvent-based inks and the screens used in the Performance Demonstrations all had a mesh count of 230 threads/inch with a direct photo stencil. The typical screen size at this facility is 50 ft^2 and about 6 screens are reclaimed daily.

Facility 2 uses a proprietary ink remover that includes at least toluene (31%), xylene (24%), methyl isobutyl ketone (19%), ethylbenzene (6%) and diacetone alcohol. Their standard emulsion remover contains at least sodium periodate. For haze removal, they use a proprietary solvent blend that contains either at least dichloromethane (90%) and isopropanol (1%), or a blend that includes sodium hydroxide and cyclohexanone. Typically, the haze remover is only used once a week at this facility. The application procedures for the alternative products were significantly different from the facility's standard methods, including use of the alternative haze remover on every screen instead of once a week. These changes may have inconvenienced the operators and influenced their opinions of product performance.

Profile of Facility 19

Facility 19 prints graphic overlays, front panels, and membrane switches. They print on plastics, metals, and paper. Their jobs usually run for 5 - 1500 impressions and approximately 70% of their orders are repeat orders. This facility uses solvent-based inks and a direct photo stencil. The alternative products were used on screens with mesh counts ranging from 156 - 390 threads/inch. Typical screen size in this facility is 30 inches x 33 inches, and approximately 60 - 80 screens are reclaimed daily.

At Facility 19, their press-side ink remover is a proprietary solvent blend consisting of at least 20% propylene glycol ethers, and petroleum hydrocarbons (<10%). Their standard haze remover is a proprietary solvent blend which contains sodium hydroxide (<15%). This facility uses the haze remover for ink, emulsion, and haze removal. The alternative product system is applied as an ink remover, emulsion remover, and haze remover separately. This change in the application procedure may have taken more time and inconvenienced the screen reclaimers, possibly influencing their opinion of the product system performance.

Performance Details from Facility 2

Except for the emulsion remover, Product System Omicron-AE performed poorly at this facility. Unfortunately, this facility became very busy during the demonstration period. The excessive workload reduced the amount of time available for using the alternative products and for experimenting with the application procedures. A total of 30 screens were reclaimed with Product System Omicron-AE over a 4 week period, but the Omicron-AE ink remover and haze remover were only used on 7 of the screens, due to poor performance. The Omicron-AE emulsion remover was used on 26 screens and worked very well.

The ink remover did not work well at this facility, which used solvent-based ink during the demonstrations. The screen reclaimer scrubbed one screen for 40 minutes trying to get the ink out of the mesh, whereas no scrubbing is needed with their usual ink remover. The alternative ink remover was chemically very different than this facility's standard product and chemical interactions could have occurred. Their usual ink removing method involved spraying solvent onto a screen in a small, closed room. This was a particularly unpleasant room in that there was a high concentration of solvents in the air, and there was also a lot of build-up of ink solids on the floor and walls. No respirators were seen when the observer was on-site, although the facility reported that respirators are usually worn in the "solvent room." Use of the alternative ink remover did not require the reclaimer to be in the ink reclamation room.

Facility 2 liked the performance of the emulsion remover very much and they thought it performed better than their usual product, even when diluted at one part emulsion remover to two parts water. The manufacturers application procedure did not instruct the printer to dilute the emulsion remover. When there was a thick ink residue left in the screen, the emulsion was more difficult to remove.

The haze remover did not reduce the haze in the screen mesh at all. The standard haze remover at this facility contains some very strong chemicals such as dichloromethane and has a very different chemical composition from the alternative haze remover. These differences could result in adverse chemical interactions on the screen. to improve performance, this facility used the alternative haze remover concurrently with Comet cleanser to remove the haze. Comet is typically used at this facility as a degreaser.

No changes in screen failure rate were noted during the demonstrations, but it could be speculated that a reduced screen failure rate would result from longer term use of the alternative products at this facility because of the abrasiveness of their usual products (such as Comet). Unfortunately, the lower abrasiveness of the alternative products may be offset by the amount of scrubbing required to get the screens clean. The reclaimer noted that his scrubbing was producing visible wear in the screen mesh.

Performance Details from Facility 19

This facility did not continue using System Omicron-AE after the initial demonstration during the observer's visit. The alternative products did not clean the screens to a level at all acceptable to this facility and they were not willing to experiment with different application procedures that may have improved performance. Also, the alternative products seemed to require more time and effort than the facility's usual procedures.

This facility has one screen reclaimer per shift and neither speak English. Forms were going to be translated into Spanish and the printing manager was present for much of the demonstrations and served as an interpreter. This facility tends to wash about 24 screens at a time in groups of eight. Using the alternative products severely interrupted the reclamation process established at this facility. This facility reclaims about 60 to 80 screens per shift. Currently, they only use one product for ink removal, emulsion removal, and haze removal. It is a very effective product, but the observer noticed it is also corrosive and emits strong vapors. Other facilities that use this product try to limit its use. This facility uses no other reclamation products and expects all screens to be completely without haze when reclamation is finished. Other facilities have less stringent haze removal requirements or expectations. The alternative product performance would probably have been considered acceptable at many other facilities. Also note that there may have been adverse chemical interactions between this facility's standard haze remover and the alternative product, because the two haze removers are chemically very different.

During the observer's visit the alternative products were used with different ink systems and several application techniques were evaluated. The type of ink did not seem to affect the alternative product performance levels. No changes in the rate of screen wear or failure were noted during the product demonstration. It is likely that the alternative products would be less corrosive than their standard product in the long term.

The ink remover did not work effectively enough for this facility. Average ink removal was observed, but the ink remover often had to be applied and scrubbed into the screen multiple times. Ink often remained in the screen at the edges of the print image and stencil. This level of removal did not compare to the results this facility has using their standard product as an ink remover, where usually no scrubbing is needed.

The emulsion remover often did not remove all of the emulsion from the screen. The emulsion remover required more scrubbing than with their standard product. Often, multiple applications were required to remove all of the emulsion. Still, emulsion tended to remain in the screen around the edges of the stencil.

The haze remover worked fairly well leaving only a light haze. This haze, which would have been acceptable at many of the other facilities participating in the project, was unacceptable for this facility. Even when the haze remover was allowed to stay on the screen for longer than the directions suggested, no appreciable improvement in performance was noted. When Facility 19 uses their usual haze remover, the haze disappears from the screen.

PRODUCT SYSTEM OMICRON-AF

Facility Profiles

The operating conditions for each facility that volunteered to reclaim their screens using Product System Omicron-AF for one month are described below. This information is provided as a basis of comparison to review the performance results of alternative product system at each of these two facilities.

Profile of Facility 4

Facility 4 prints decals on plastic sheets. A typical run is 3,000 sheets, and approximately 50% of their orders are repeat orders. Of the 30 - 40 employees at this facility, approximately 4 are involved in screen reclamation. All printing is done with UV-cured inks. All screens used in the Performance Demonstrations were polyester (calendared) with a typical mesh count of 390 threads/inch with a direct photo stencil. The average screen size at this facility is 35 inches x 38 inches and approximately 6 screens are reclaimed daily.

As their standard screen reclamation products, Facility 4 uses two proprietary products for ink removal, and also uses proprietary products for emulsion and haze removal. These products are sold by a manufacturer not participating in the performance demonstration. The MSDSs for all of these products state that they contain no carcinogens, no ingredients with TLVs or PELs, and no petroleum derivatives. The application procedure for the alternative ink remover recommended that the ink be wiped off the screen. This facility's standard ink removal practice is to rinse the screen. The screen reclaimers were trained on this change in application method, but the extra physical effort required may have influenced their opinions of the product performance. The emulsion and haze remover application techniques are very similar for the alternative and standard products.

Profile of Facility 18

Facility 18 prints graphic overlays for the electronics industry and nameplates and panels. All of their printing is done on plastics. Their typical run length is 16 hours and approximately 80% of their orders are repeat orders. There are approximately 40 employees at this facility, three of which are involved in screen reclamation activities. During the Performance Demonstration, this facility used solvent-based inks and they used both a direct photo stencil and a capillary film stencil. High tension monofilament polyester mesh (untreated) screens with mesh counts ranging from 110 - 460 threads/inch were used. Typical screen sizes in this facility are 1,596 in^2 or 952 in^2, and approximately 10 - 15 screens are reclaimed daily.

As their standard ink remover, Facility 18 uses a proprietary solvent blend that contains at least pentanedioic acid and dimethyl ester (<20%). Their standard emulsion remover is a proprietary aqueous mixture with at least sodium periodate. For haze removal, this facility uses a proprietary aqueous mixture that contains sodium hydroxide (<15%). Facility 18 typically rinses the ink remover from the screen, but the alternative product required the screen reclaimer to wipe the ink off the screen. The extra physical effort required may have influenced the screen reclaimers opinions of the product performance. The emulsion and haze remover application techniques are similar for the alternative and standard products.

Product System Omicron-AF Performance Details from Each Facility

Performance Details from Facility 4

After using Product System Omicron-AF for two weeks, Facility 4 decided they did not want to continue participation in the performance demonstrations. When using the screens reclaimed with Omicron-AF in subsequent print jobs, the printer noticed a ghost image. He cleaned the screens again using his own product to remove the haze and was then able to reuse the screens. Faced with a tight production schedule, the printer was unable to continue using Product System Omicron-AF since additional time would be required to reclean the screens with his standard product.

After using the ink remover, the printer evaluated the screen and reported that the ink was removed effectively on 80% of the screens. However, after using the emulsion remover, the printer noted that on every screen an ink residue remained in the stencil area. He felt that this ink residue normally would not have been a problem, because his haze remover could remove it. The alternative haze remover could not.

The printer was pleased with the performance of the emulsion remover. He reported that it removed the stencil completely and easily.

The performance of the haze remover was unacceptable at this facility. When following the manufacturers application instructions, the haze remover reduced the residue, but did not remove it or significantly lighten the ink stain on the mesh, even after vigorous scrubbing and a long high pressure water wash. A ghost image was clearly visible on subsequent print jobs which required the printer to clean the screen again with his standard haze remover.

To improve the product performance, the printer varied several conditions: he increased the soaking time on the screen for the ink remover and the haze remover, he increased the quantity of ink remover and haze remover, he sprayed the haze remover on a scrubber pad instead of directly onto the screen, and he tried drying the screen before using the haze remover. These techniques did not improve the performance of the product system. During the two weeks of demonstrations, product performance was quite consistent as were the demonstration conditions (e.g., ink type, emulsion type, screen condition). The printer did not think further use of the product would provide any different data.

Overall, the printer did not notice any change in screen failure rate over the time period that the alternative products were in use, however, he did need to clean each screen a second time with his own haze remover in order to be able to reuse it. The printer thought this haze would build up on the screen and would eventually prevent the emulsion from adhering to the screen.

Performance Details from Facility 18

Facility 18 used Product System Omicron-AF for four weeks. The press area supervisor was asked to comment on the performance of the system several times during the performance demonstration period. He felt that, in general, the ink remover and emulsion remover products worked as well as the products they were previously using. The haze remover, however, did not give acceptable results, and they stopped using it during the first week of the demonstrations.

The ink remover worked well in most cases. Two of their solvent-based inks which were difficult to clean with their regular products also required more effort with the alternative products. The facility's standard procedure for these inks is to apply haze remover twice after reclaiming. Ink residue left by the alternative chemicals required this practice to be continued during the performance demonstration.

The emulsion remover performed well on all screens and stencils. The reclaimer noted that the stencil dissolved easily with this product. The haze remover did not work well. After reclaiming several screens, it was determined that the screens could not be reused until the facility's regular haze remover was applied to them. Facility 18 therefore discontinued the use of the alternative haze remover.

Screen size at this facility was relatively uniform, and careful controls were placed on screen condition and tension. Retensionable frames were used exclusively. The screens were brought to the reclaiming area with most of the ink removed from them already, having been carded off at the press. Facility 18 had tried other products which were advertised as "safer", and they had one bad experience where one of the products damaged their plumbing system. The same person reclaimed the screens and evaluated the print image quality. This employee was knowledgeable about the entire screen printing process.

The products in System Omicron-AF were not observed to be detrimental to the screen mesh, the printing equipment during the performance demonstration. Print image quality was not affected.

PRODUCT SYSTEM PHI

Facility Profiles

The operating conditions for each facility that volunteered to reclaim their screens using Product System Phi for one month are described below. This information is provided as a basis of comparison to review the performance results of alternative product system at each of these two facilities.

Profile of Facility 5

Facility 5 makes interior signs, marks parts, and prints identification badges. Primarily, they print on plastics and on metals. A typical run is 100 pieces, and approximately 80% of their orders are repeat orders. Of the 15 employees at this facility, approximately 3 are involved in screen printing operations and 1 employee is responsible for screen reclamation activities. The facility uses a variety of solvent-based inks including vinyl-based inks, epoxy inks and a multipurpose ink. They use capillary film for their emulsion. All screens used in the Performance Demonstrations were polyester (no treatment) with a typical mesh count of 305 threads/inch. The average screen size at this facility is 20" x 20" and approximately 2 - 3 screens are reclaimed daily.

The standard ink remover used at Facility 5 is a blend which contains 55% - 56% propylene glycol ether. For emulsion removal, they use a product which contains sodium metaperiodate (5%) and their standard haze remover contains sodium hydroxide (<15%). The application procedure for the alternative product system was very similar to the standard procedures used at this facility.

Profile of Facility 23

The majority of the products printed by Facility 23 are front panels, overlays, and labels on plastics. They also do some printing on paper, metals, and glass. Run lengths are typically 150 impressions, and approximately 82% of their business is for repeat orders. There are less than 5 employees at this facility and two are involved in screen reclamation operations. The facility uses several types of solvent-based inks including vinyls, acrylic vinyls, and epoxy inks. They use a dual-cure emulsion and a multifilament (untreated) polyester mesh. Mesh counts used in the Performance Demonstrations ranged from 195 - 305 threads/inch. The average screen size at this facility is 1,305 in^2 and approximately 3 - 5 screens are reclaimed daily.

For ink removal, Facility 23 uses a proprietary blend which contains at least xylene, propylene glycol methyl ether, and diacetone alcohol. Their standard emulsion remover product is 100% sodium periodate, and their standard haze remover is a proprietary aqueous mixture which contains sodium hydroxide (<15%). This facility did not have to modify their product application procedures when switching from their standard ink and emulsion removers to the alternative products. The alternative haze remover required up to a 30 minute wait, which tended to disrupt the production schedule at this facility. This inconvenience may have influenced the printers opinion of the products.

Performance Details from Facility 5

At the conclusion of the Performance Demonstrations, the printer was asked to compare the performance of each component of Product System Phi to the system they previously used at this facility. Overall, the printer felt the emulsion remover worked better, and the ink remover and the haze remover did not work as well as their previous reclamation products.

On most screens the printer reported that the ink was removed effectively, however, there was an light to moderate ink haze remaining on 35% of the screens after using the ink remover. This facility found the ink remover performance was the same whether used on vinyl inks or on epoxies. Although not included in the Performance Demonstration protocol, the printer used this product as an in-process ink remover, not just as a reclamation ink remover. He found it would start to deteriorate the stencil if left on the screen for more than a few seconds. By spraying on the ink remover, wiping it off very quickly, and allowing the screen to dry before printing, he was able to use it in-process without affecting the print quality.

The printer was very enthusiastic about the emulsion remover, commenting that it consistently dissolved the stencil very quickly with minimal effort. After the conclusion of the Performance Demonstrations, he requested more information on the product so he could continue to use it in his facility.

The haze remover performance was not up to the standards of this printing facility. When following the manufacturer's application instructions, the haze remover did not remove the haze satisfactorily. The printer commented that he thought the haze remaining on the screen would deteriorate the screen over time. To improve the performance, the printer let the haze remover sit on the screen overnight (instead of the recommended 3 - 5 minutes), he wiped the product off with rags before pressure washing, and he tried using more ink remover hoping that there would be less ink stain later. None of these techniques improved the performance of the product. The printer did note that he preferred the very mild odor of this product to the strong, unpleasant odor of his own haze remover.

In reviewing the data from the printer's evaluation forms, there does not seem to be a correlation between any specific screen condition (e.g., ink type, ink color, number of impressions) and variations in the product performance. Overall, the use of Product System Phi had no deleterious effects on the screen mesh or on the subsequent print quality image and the printer did not notice any change in screen failure rate over the time period that the alternative products were in use.

Performance Details from Facility 23

Generally, this facility felt the emulsion remover worked well, but they were not satisfied with the ink remover and the haze remover of Product System Phi. While the actual performance of the alternative products was often adequate, the procedures involved with using the products disrupted the facility's routine. After two weeks of demonstrations, this facility discontinued their participation in the project and only submitted data on 8 screens. In addition to problems with the product application procedures, this facility experienced personnel problems that contributed to their decision to discontinue their participation after two weeks. The main screen printer/screen reclaimer involved with the demonstrations was absent for two weeks in the middle of the project. No screen reclamation with the alternative products continued during her absence. When she returned, so much work had accumulated that the facility decided they could not spare the time for the demonstrations.

The printer found the performance of the ink remover to be inconsistent. When using metallic inks, the alternative ink remover worked better than their standard product. With other ink types, the ink remover did not effectively remove the ink from the edges of the stencil and it did not remove as much ink from the screen as their standard product. Their standard ink remover is a solvent blend whose chemical composition is very different from that of the alternative ink remover. On older screens that have been reclaimed many times, adverse chemical interactions between the standard product and the alternative product could occur due to these differences.

The printer felt the emulsion remover was as effective as their standard product, and it dissolved the stencil faster than their standard emulsion remover. Product System Phi haze remover required more contact time with the screen than this facility's usual haze remover. This additional waiting time impeded the facility's ability to reuse screens at the needed rate. In addition to the inconvenient wait time, the haze remover often did not reduce the haze sufficiently and the facility had to follow up with their usual product before the screen could be reused. The printer noted that the haze remover was less irritating to the respiratory system than their usual haze remover.

During the two weeks the products were used in this facility there was no noticeable mesh deterioration, no change in the screen failure rate, and no change in print quality.

PRODUCT SYSTEM ZETA

Facility Profiles

The operating conditions for each facility that volunteered to reclaim their screens using Product System Zeta for one month are described below. This information is provided as a basis of comparison to review the performance results of alternative product system at each of these three facilities.

Profile of Facility 6

Facility 6 prints store displays, transit markings, and movie posters on plastics and paper. Their typical run length is 250 - 300 sheets, and approximately 5% of their orders are repeat orders. Of the approximately 25 employees at this facility, 1 - 3 are involved in screen reclamation. Currently, they used solvent-based, water-based, and UV inks, but they are in the process of discontinuing their use of solvent-based ink systems. All screens used in the Performance Demonstrations were made of a polyester mesh with thread counts ranging from 280 - 420 threads/inch. The average screen size used at this facility is 35 ft^2 and 10 - 15 screens are reclaimed daily.

Facility 6 uses a proprietary blend which contains propylene glycol ethers (<50%) as their standard ink remover. Their emulsion remover is a proprietary aqueous mixture with periodate salt (<10%). For haze removal, they use a proprietary blend consisting of at least sodium hydroxide, potassium hydroxide and propylene glycol ether. The application procedures for the alternative products were similar to the methods for applying the standard products.

Profile of Facility 7

Facility 7 prints roll labels, fleet markings, point of purchase displays, and decals. A typical run length is 275 sheets. There are less than 5 screen printing employees at this facility. The facility uses both UV ink and solvent-based ink. During the Performance Demonstrations they used a capillary film emulsion and the screen mesh was an abraded polyester. Mesh counts ranged from 230 - 390 threads/inch. The screen size typically used in this facility is 60" x 52", and 10 - 12 screens are reclaimed daily.

For ink removal, Facility 7 uses lacquer thinner, as well as a proprietary product sold by a manufacturer not participating in the performance demonstration. The MSDS states that this product contains no carcinogens, no ingredients with TLVs or PELs, and no petroleum derivatives. Their standard emulsion remover is a proprietary aqueous mixture which contains periodate salt (<10%). As a haze remover, they use a proprietary aqueous mixture with sodium hydroxide (<15%). At this facility, the application procedures for their standard products were very similar to the methods recommended for the alternative products. However, the facility only applies their standard haze remover to about one screen per month. The alternative haze remover was needed for all screens. This additional effort may have influenced the screen reclaimers opinions of the alternative product system performance.

Profile of Facility 15

Facility 15 prints store fixtures, banners and point-of-purchase displays. They primarily print on plastics, but they also do some jobs on paper, metal, and wood. A typical run is 800 sheets and 70% of their orders are repeat orders. Of the approximately 5 employees involved in screen printing at this facility, 2 are involved in screen reclamation activities. Several different types of ink are commonly used at Facility 15, including vinyls, epoxies and UV-cured inks. All screens used in the Performance Demonstrations were polyester and a direct photo stencil emulsion was applied. Mesh counts during the demonstration period ranged from 156 - 305 threads/inch. The average screen size used at this facility is 35 inches x 45 inches and 4 - 5 screens are reclaimed daily.

For ink removal, Facility 15 uses acetone, as well as a proprietary product sold by a manufacturer not participating in the performance demonstration. The MSDS states that this product contains no carcinogens, no ingredients with TLVs or PELs, and no petroleum derivatives. For emulsion removal, they use a proprietary aqueous mixture with at least sodium periodate. Their standard haze remover is an aqueous blend consisting of potassium hydroxide (27%) and tetrahydrofurfuryl alcohol (11%). At this facility, the application procedures for their standard products were very similar to the methods recommended for the alternative products. However, the facility only applies their standard haze remover to about 5% of their screens. The alternative haze remover was needed for all screens. This additional effort may have influenced the screen reclaimers opinions of the alternative product system performance.

<u>Product System Zeta Performance Details from Each Facility</u>

Performance Details from Facility 6

This facility had mixed success with System Zeta. The demonstrations were complicated by the fact that the screen reclaimers spoke almost no English and the forms had to be translated into Spanish. Two different reclaimers participated in the demonstrations, but another person was involved to either translate the reclaimer's forms or to write down results. Because of this situation, the observer was not confidant that all the information received was accurate. Another confounding factor was that the product arrived late at the facility and the observer was not present to assist the printer with the application instructions and with trouble-shooting, as was done at most other facilities. It is possible that better results could have been achieved had the observer been present.

At Facility 6, the ink remover did not work as well as their usual product. During the demonstrations, this facility used the alternative products on screens with solvent-based, UV-cured, and water-based inks. The alternative ink remover performed poorly with solvent-based inks, it worked well on one screen with water-based inks, and performance was mixed on screens with UV inks. Facility 6 needed to use their regular remover to get the ink out of several of the screens after using the alternative ink remover.

This facility had mixed results with the emulsion remover. In general, when the emulsion remover was used at a strength of three parts of product to one part water, or stronger, the stencil dissolved quickly. At weaker concentrations, the emulsion remover worked much more slowly than their usual product and the printer needed to use their usual emulsion remover to get the screens clean. However, these results were not consistent, and on some screens where the stronger formulation was used, the stencil did not dissolve completely.

The haze remover worked very poorly for this facility. It did not seem to reduce haze produced by UV-cured or solvent-based inks and it was not used with water-based inks.

Performance Details from Facility 7

The alternative products arrived at Facility 7 during a very busy period. The facility's initial response to the alternative products' performance was negative. The poor initial performance combined with increased activity at the facility led to a situation where little information was collected on alternative product performance. This facility also received the alternative products shipment late and the observer did not have the opportunity to assist the printer with the application technique or to suggest procedures to improve performance. This assistance was given through telephone conversations between the observer and the facility contact, however, this may not have been as effective as in-person support.

The ink remover performance at Facility 7 was poor. The facility was particularly unhappy with the directions which said to let the ink remover sit on the screen. The ink remover dried quickly into the screens, stuck into the mesh and it was then completely ineffective at removing ink. This facility was only able to use the ink remover if they applied additional ink remover and began wiping it out of the mesh immediately. These changes improved the performance of the ink remover slightly, but often the facility used their usual ink remover to remove all ink from the screens. Facility 7 did use the ink remover on one screen with UV ink and found it worked much better. As their standard ink remover, this facility uses a lacquer thinner in some cases. Adverse interactions could occur when using the alternative ink remover because its chemical composition is very different from lacquer.

Initially, the facility diluted one part emulsion remover to five parts water. At this concentration, the emulsion remover did not dissolve the stencil unless the product was reapplied. When they changed the dilution to one part emulsion remover to three parts water, the stencil dissolved easily with little scrubbing effort. The facility did have problems with the emulsion remover drying quickly into the mesh. Wiping the emulsion remover immediately off of the screen aided the product's performance.

The haze remover was not effective at this facility; they did not think that the haze remover worked at all. Facility 7 only filled in the haze remover information on the data sheets for one screen, although they tried it on several screens and the performance was consistently disappointing.

Performance Details from Facility 15

Facility 15 did not like System Zeta compared to their usual products. Under most conditions, they were unhappy with the performance of all three alternative products. Because the alternative products did not work well, the facility recleaned their screens with their usual products after each demonstration. This double cleaning greatly increased the time required for screen reclamation. Each time the facility tried the alternative products, their confidence in the product's abilities to clean the screen decreased making it even harder to convince the facility to continue with the demonstrations. They submitted data on only eight screens.

The ink remover did not effectively remove the ink from the screens unless it was applied several times. Compared to their standard product, more scrubbing was required and the facility often had to follow up with their usual ink remover to get the ink out of the screens. The standard ink remover is very different chemically than the alternative product. This difference may cause adverse chemical interactions.

At Facility 15, the emulsion remover had to be applied multiple times to effectively clean the screens. Using the emulsion remover undiluted did not eliminate the need for a second application to remove all emulsion from the screen. Even with multiple applications of the undiluted emulsion remover, Facility 15 often had to use their usual emulsion remover to get the screens to the level of cleanliness that they wanted.

The haze remover required harder scrubbing than their usual product and did not seem to reduce the haze. Once again, Facility 15 had to resort to using their usual haze remover to reduce the haze to an acceptable level.

The performance of the alternative products did not seem to be affected by the types of ink or by ink color, although there was a possibility that the alternative products worked slightly better with UV-cured inks than with solvent-based inks. Since the data available was so limited, it is not possible to draw any conclusions on correlations between product performance variations and screen conditions. No screen side effects were noticed during the performance demonstrations, although increased scrubbing will produce a greater level of mesh abrasion, which may in turn lead to higher screen failure rates.